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Evening Meeting.

Monday, March 18th, 1872.

Admiral The RIGHT HON. THOMAS, EARL OF LAUDERDALE, K.C.B., in the Chair.

NAMES OF MEMBERS who joined the Institution between the 5th and 18th March, 1872.

LIFE.

Suffield, Right Hon. Lord, Lt.-Col. Norfolk Art. Mil.
Hoole, F. W., Lieut. 2nd West York Rifle Vols.
Lumsden, Henry, Capt. London Scottish Rifle Vols.

ANNUAL.

Grace, Sheffield, Major h.-p. 86th Regt.
Evans, R. Harding, Capt. Royal London Militia.
Greenwood, Frederick, Lt.-Col. 6th West York Rifle Vols.
Coles, Alfred, Lt.-Col. 1st Surrey Rifle Vols.
Oxley, John S., Lt.-Col. 19th Middlesex Rifle Vols.
Read, Philip, Captain 19th Middlesex Rifle Vols.
Pearson, M. B., Captain 2nd Middlesex Art. Vols.
Adair, A. S., Captain Edm. Royal Rifles.
Milne, H., Maj.-Gen. Bengal Army.
Conolly, Arthur, Lieut., Bengal Staff Corps.
Forster, William, Lieut. 60th Rifles.
Clery, C. F., Captain 32nd Regt.
Hay, W. E., Major, late Indian Army.
Tully, Thomas, Lieut. 28th Middlesex Rifle Vols.
Lloyd, N. Y., Lieut. 82nd Regt.
Read, C. E., Lieut. R.N.
Boileau, C. H., Captain 61st Regt.
Hunt, Chas. B., Lieut. 4th Surrey Rifle Vols.
Puckle, Alfred D., Lieut. London Scottish Rifle Vols.
Feilden, R. J., Col. late 60th Royal Rifles.
Hilton, J. W. D., Lieut. 3rd Hussars.
Hannen, G. G., Captain R.A.

ON ECONOMY OF FUEL IN SHIPS OF WAR.

By T. Symes Prideaux, Esq., C.E.

It has always appeared to me that the question of "Economy of Fuel in Steam Ships of War" has never received that amount of attention to which the importance of the subject entitles it. All those considerations which render it so desirable to obtain steam power on land for our manufacturing and other purposes, with the smallest possible expen-

diture of fuel, are increased in force and heightened in importance when applied to the case of ships which traverse the ocean. Economy of fuel in a ship of war confers the power of selecting one or more from a list of many advantages. It is equivalent to a smaller, handier, and cheaper ship, or to thicker armour and heavier armament, or to higher speed, or lastly, but not least in value, to the capacity for remaining under steam for a longer period.

Supposing two rival powers with navies of equal force, but that the ships composing the Navy of one were able to maintain their stations at sea without resorting to a coaling depôt twice as long as those of the other, who can fail to recognise in this faculty an element of superiority that would, in the event of war, find ever-recurring opportunities of exhibiting itself?

Imagine two ironclads of the largest size and armament, costing say £300,000 each, and having stowage in their coal bunkers for 800 tons of coal, and that this quantity amounts, in the case of one, to eight days' consumption, and in that of the other to sixteen, who can fail to recognise in the latter, such a much greater capacity for doing duty as a ship of war, that almost any sum would be well expended on the former, to obtain the same economy of fuel? Were it requisite to construct her furnace bars and doors of silver to effect this object, the price should be cheerfully paid. Unfortunately, it must be confessed that our own Navy is sadly behindhand in this element of efficiency.

The comparison I have made of two sister ships, one of which burns only half as many coals as the other, is, I believe, by no means an exaggerated picture of the diminished consumption of coal per horse-power in steam vessels; which has actually taken place since my attention was first directed to this subject twenty years ago. At that period I pointed out that the consumption of coal in marine engines was excessive, and capable of being reduced one-half; but my statements on that head proved unpalatable, and found little credence amongst the engineering authorities of the day. I have lived, however, to see them verified, and also to come to the conclusion that they were so much within the mark as to be capable of being repeated, or in other words, that our consumption of coal per horse-power in marine engines may again be halved.

As long ago as 1854, at almost my first interview with Sir Baldwin Walker, who was then Comptroller of the Navy, I stated that Her Majesty's ships were burning twice the weight of coal per h.-p. that would be used in a not very distant future, that all the knowledge was in existence to enable this saving to be effected, and that it ought to be applied at once. I have since had the satisfaction of sending Sir Baldwin an extract from the Naval Correspondent of the *Times*, showing that the economy predicted had been more than attained, and I was able to append a reference, with the motto, *Litera scripta manet*, showing that the result had been effected by the precise channel pointed out by me in my treatise on Economy of Fuel, published in 1853. In 1855, after my return from the Baltic, I was so impressed with the waste of fuel and the inordinate heat of the stoke-holes I witnessed in the fleet—the candles being melted in the Officers' cabins

in the gunboats—that I addressed a letter to the Admiralty offering to reduce the average consumption of fuel one-half, and the temperature in the stoke-holes 20°, but the offer was so distasteful to the Engineering Department, that they did not even vouchsafe a reply.

In 1857 I also offered, for the third time, to save 50 per cent. in the fuel expended per horse-power obtained, saying, " I state with confidence " that this amount of saving may be effected by the channels I have " indicated. In short, the question really at issue is whether a waste of " 50 per cent. of fuel is to be persisted in, for the sake of the personal " interests and feelings bound up with the present arrangements."

In January, 1859, I submitted a memorandum to the Admiralty, from which I subjoin the following extract:—" For five years past I " been labouring, in season and out of season, to inculcate the import- " ance—nay, the absolute necessity—of allowing a proper *flame-space* " (large enough for the most bituminous fuel likely to be used) between " the grate bars and the tubes, if anything approaching perfect com- " bustion with its concomitant absence of smoke is to be attained. In " tubular boilers as they have been, and I fear I must say still are, " commonly constructed, the flame arising from the last foot or two feet " of bars, is extinguished by entering the tubes before its development " is complete, producing smoke instead of heat. The necessity of pre- " serving the products of combustion from contact with metallic " surfaces till after inflammation is complete, to obtain perfect com- " bustion appears to me most obvious, yet it has been all but entirely " overlooked in the construction of boilers up to the present time—the " existing boilers in the Navy to wit."

The researches of the celebrated French chemist Regnault, have given us a far more accurate knowledge of the laws governing the amount of heat in steam of different elasticities and temperatures, than was possessed in the the time of Watt, so much so, that within very narrow limits of error, we may now be said to possess the necessary data for treating exhaustively the question of the steam power practically attainable by the combustion of a given weight of fuel.

The question of the economic production of steam-power naturally resolves itself into two perfectly distinct branches, viz., first, how to evaporate the greatest weight of water with a given weight of combustible, hinging on the structural arrangements and management of the furnace and boiler; and secondly, how to obtain the maximum mechanical effect from the steam raised, dependent upon the construction and management of the engine. The first branch being chiefly concerned with chemistry and physics, the second with physics and mechanics.

To evaporate the greatest weight of water from the fuel employed involves two considerations:—First, the generating from that fuel the utmost amount of heat it is capable of rendering, to be accomplished by effecting perfect combustion in the furnace. Secondly, the transference of the largest practicable proportion of this heat to the water in the boiler, to be attained by the judicious arrangement of its heating surface. The first, a question beset with complication; the second, one of comparative simplicity.

Coal is so much more extensively used than any other combustible for the production of steam power, that in so condensed an exposition of the subject as the present must necessarily be, it will be most profitable to restrict our remarks to its use.

At the outset of our enquiry we are confronted with the question, What proportion of the whole heat coal is capable of yielding, do we succeed in utilising in raising steam, or, in other words, transferring to the water in the boiler?

After carefully investigating the subject, the conclusion at which I have arrived is, that we cannot assign to carbon a smaller heating power than 9000° centigrade, which is equivalent to the capacity for evaporating fifteen times its own weight of water from 100° Fahrenheit. The average duty obtained in marine boilers at present must, I apprehend, be set down at not more than $7\frac{1}{2}$ lbs. of water evaporated by 1 lb. of coal, or, in other words, we only obtain half the duty which theory assigns to the fuel. Let us console ourselves for so humiliating a result by the reflection, that this very large margin for waste is as encouraging to our future prospects as it is discreditable to our present practice.

The heat obtained from coal is evolved by the chemical union of the hydrogen and carbon of the coal with the oxygen of the atmosphere, forming with the former substance, water, and with the latter, carbonic acid, and just in proportion to the exactitude with which we transform all the hydrogen of the combustible into water, and all its carbon into carbonic acid, without *admitting any superfluous air*, will be the temperature produced, and (other conditions being equal) the amount of water evaporated.

Different coals vary in their component parts, and in the proportion of these to each other. Carbon and hydrogen, however, are the essential constituents of all as far as their heating capacities are concerned, and I shall assume as a convenient standard that 100 parts of coal consist of 80 parts of carbon and 5 of hydrogen, leaving out of view the other elementary substances which enter into their composition (consisting of oxygen, nitrogen, sulphur, and incombustible ashes, composed principally of sand and clay), as non-essential to the subject under discussion. There is a convenience in assuming these proportions of 80 carbon and 5 hydrogen for the composition of coal, for since hydrogen furnishes, weight for weight, four times as much heat as carbon, the 5 parts of hydrogen will furnish 20 per cent. of the whole heat, and the 80 parts of carbon 80 per cent., being the same proportionate part of the heat as it forms by weight of the fuel, and thus the heating power of coal, as a whole, may be treated as equivalent to an equal weight of carbon.

The hydrogen in coal exists in chemical combination with carbon, and when heated without the access of air, passes off with the carbon, with which it is combined in the gaseous form as carburetted hydrogen, a gas consisting of 1 part by weight of hydrogen and 3 of carbon, being in fact the coal gas we use for illuminating purposes. 100 lbs., therefore, of coal containing 5 parts of hydrogen and 80 parts of carbon in the 100 lbs. would yield 20 lbs., or 525 cubic feet of this gas, and 65 lbs. of solid carbon, or coke.

As the 5 parts of hydrogen in coal gas furnish 20 parts of the total heat of the coal, and the 15 parts of carbon 15 parts, the two combined contain 35 per cent. of the total heating power of the combustible. But here I must not omit to draw your attention to the important fact that if, through the defective regulation of the air supply of the furnace, you cause half this gas to pass off up the chimney unburnt, the heat wasted is more than $17\frac{1}{2}$ per cent., because the gas has robbed the furnace of the heat employed in its own volatilisation or transformation from the solid into the gaseous form. $7\frac{1}{2}$ per cent. is by no means an over-estimate of the heat subtracted from the duty of the carbon by this process, and hence we arrive at the result that, in the case of a furnace so managed as to dissipate half the carburetted hydrogen unburnt, the waste of fuel through this channel alone reaches 25 per cent. That this amount of waste does in practice often take place from this cause is unquestionable, since I have in numerous instances witnessed this percentage of saving effected by simply altering the conditions governing the air-supply of the furnace during the first five minutes after coaling, the period at which, under the ordinary system of furnace management, or rather mismanagement, this great waste of unconsumed gas takes place. In short, I have rarely seen an instance where experiment did not prove that, with bituminous or north country coal, a saving of not less than two-thirds of this amount, or from 17 to 18 per cent. was obtainable by these means, so that I feel justified in saying that in furnaces as constructed and fired at present, *i.e.*, with no provision for adapting the air supply to the changing conditions and consequent varying requirements of the fuel, this waste of a large proportion of the gaseous constituents of the coal must be regarded as the normal state of things, and inseparable from the rude, defective, and unintelligent system of furnace-management pursued.

Although, as a general rule, the combustion of the carbon of the fuel is effected without the large proportion of waste attendant upon that of its gaseous constituents, yet occasionally—in such a case, for instance, as one of which we have recently heard, where, in the Southern Pacific, the flames proceeding from the top of the funnel of one of Her Majesty's ships at night were actually mistaken for an eruption from a volcano in one of the peaks of the Andes—a great waste of carbon occurs. Such a state of things as this, however, can only exist with most defective furnace arrangements, involving a really frightful sacrifice of fuel.

I will endeavour to describe the conditions under which alone I consider such an occurrence as described to be possible. The flame emitted does not extend from the furnace through the flues to the funnel head, as many suppose, but is produced by carbonic oxide gas (generated in the furnace through deficiency of the air supply), passing off at such a high temperature as to preserve the temperature necessary for ignition, after mixing with the $2\frac{1}{2}$ volumes of atmospheric air required to furnish the oxygen needful for its transformation into carbonic acid. Now, since an atom of carbon, in combining with one atom of oxygen, and becoming carbonic oxide, only yields one-third of its heating power, the remaining two-thirds being set free upon its combining with the second equivalent of oxygen, and becoming carbonic

acid, it follows that two-thirds of the heating power of all the carbon passing off as carbonic oxide is wasted.

Even this statement does not adequately represent the frightful sacrifice of heating power, of which flames passing off at the funnel head are the sign; for small as may be the proportion of the heating power of the fuel developed in the furnace, of this small proportion, an unusually large part is wastefully dissipated into the atmosphere, as is shown by the high temperature of the gases issuing from the funnel, such high temperature being the result of the diminished subtraction of their heat by the surface of the tubes, consequent upon the latter being coated with soot. Unless there be something more than ordinarily faulty, either in the construction of the furnace, or the mode of firing pursued, the coating of the tubes with soot may be regarded as the necessary precedent to the exhibition of flame at the funnel-head, as in fact begetting the conditions under which it occurs. A deposition of soot on the interior of the tubes, simultaneously diminishes the draft, and in a still greater ratio the steam generated. Heavier firing is resorted to to keep up steam, with the effect of aggravating the previously existing evils. Flame makes its appearance at the top of the funnel, and a vicious circle of evil consequences is produced which mutually re-act upon and aggravate each other.

The waste of a large proportion of the coal gas or carburetted hydrogen contained in the fuel, during say the first third, or first five minutes of the coaling interval, which ordinarily takes place under the present system of furnace management, by no means pre-supposes such conditions in the arrangements and working of the furnace, as would subsequently lead to the dissipation of carbon as carbonic oxide. The fatal sign of flame at the funnel head, however,—announcing as it does a thick layer of ignited carbon on the bars, and an insufficient air-supply,—may be accepted as indicative of conditions being present in the furnace, which must have been productive of a more than average waste of carburetted hydrogen at an earlier period.

Great as are the evils which we have been reviewing, proceeding from a deficient air supply, they are rivalled, and, perhaps, having regard to its greater frequency (during the latter portion of the coaling interval), exceeded in amount as a whole, by the opposite fault of too much air entering the furnace. The excess of air acts prejudicially, not by interfering with the perfect combustion of the carbon, none of which under these altered conditions can escape transformation into carbonic acid, but by diluting the temperature of the furnace by the admixture of cold air, which, after receiving a large accession of temperature, passes off through the funnel, robbing the furnace of heat that should have been employed in raising steam. All good firemen are awake to the evil consequences of allowing their fire to burn through at the back, admitting a free ingress of air, or the still more fatal results of perforations in the door or bridge. Let us analyse the conditions under which these evil consequences ensue, and the causes on which they depend:—

One hundred pounds of coal require, in order to obtain the equivalent of oxygen necessary for its perfect combustion (or the transformation of all its hydrogen into water and all its carbon into carbonic acid)

15,000 cubic feet of air, and the temperature resulting may, to speak in round numbers, be set down at 4,200°. No such exact adjustment of the air-supply is possible in working a furnace, and there are reasons why, in practice, a better result is obtained by admitting an increased quantity, say $\frac{1}{3}$rd more than the amount required to furnish the exact combining equivalent of oxygen. Assuming, therefore, the admission of $\frac{1}{3}$rd more, or 20,000 cubic feet, we get a temperature of 3150°, of which, taking the temperature of the gases when they leave the heating surface of the boiler and enter the funnel at 600°, 81 per cent. is absorbed by the heating surface of the boiler, and profitably employed. If instead of 20,000 feet twice the quantity, or 40,000 feet, enter the furnace, we only get a temperature of 1575°; and supposing the temperature of the gases entering the stack to be the same, viz. 600°, we only get 62 per cent. absorbed by the heating surface and performing the duty of raising steam. In reality, however, since twice the volume of gas traverses the flues in the same time, it must pass over the heating surface at twice the velocity. The area of the heating surface therefore becomes halved in proportion to the quantity of gas passing, and, as a consequence, the products of combustion will pass off at a higher temperature, so that in reality less than 62 per cent. will be absorbed.

Thus, paradoxical as at first sight it may appear, when a diminished temperature of the products of combustion is caused by their volume being increased by an excess of cold air entering the furnace, the lower their temperature in the furnace, the higher will be the temperature at which they will pass off through the funnel, still further magnifying the waste of fuel invariably attendant upon the existence of conditions which diminish the temperature by facilitating the entrance of superfluous air.

Our inquiries have landed us at the conclusion, that the more narrowly the conditions attendant upon the working of a furnace are investigated, and the more closely the duty performed is compared with these conditions, the more manifest does it become that the first of the two branches or divisions into which the question of the economic production of steam power naturally resolves itself, viz., "How to evaporate the greatest weight of water with a given weight of combustible?" is for all practical purposes almost synonymous with the question, "How to admit the right quantity of air to the furnace?" A competent heating surface must, as a matter of course, be provided; but it is not in respect to the absorption of heat, but in respect to its generation, that our present practice is so sadly in arrear, and that such a vast scope for improvement is visible.

How are we to realise in practice this all-important and indispensable condition to economic furnace management, the due adjustment of the air-supply, that is, the supply of such a quantity as a *whole*, and so distributed as to *period*, as to convert all the hydrogen of the fuel into water, and all the carbon into carbonic acid, with the admixture of the smallest possible quantity of surplus air? However difficult the task may be, it is nevertheless most certain that by how much we deviate from the correct quantity, either more or less, by so much do we fall short of "generating from the combustible, the utmost amount of heat it is capable of furnishing," for the

laws of chemical affinity are unchangeable and ubiquitous. In short, this danger of erring on either side, may be said to be the Scylla and Charybdis to which voyagers in search of perfection in furnace management are exposed, and safety is only to be attained by studying the landmarks and bearings so carefully as to be able to steer with confidence a middle course.

The supply of air which enters a furnace depends upon the ratio existing between the *pull* exerted by its chimney or stack and the *obstruction* caused by the layer of fuel on the grate-bars, and a more or less confined ashpit. The force of the pull, or suction, exerted by the stack, is the difference in weight between the column of heated gas it contains and a similar column of air at the temperature of the atmosphere. The higher the temperature and the taller the stack, the greater the force of the draft, and *vice versâ*. The great practical difficulty which stands in the way of obtaining the regular flow of the right quantity of air into the furnace, is the fact that the demand is not a *constant*, but a *varying*, quantity. Were the same conditions always present in the interior of the furnace, that is to say, the same thickness of fuel on the grate bars, and the various layers of this fuel at similar stages of combustion, so as to cause the supply of air demanded by the wants of the fuel to be uniform, then, the average rarefaction or draft in the stack being once attained, a steady supply would enter the furnace, proportionate to the thickness and closeness of the layer of fuel, the area of the grate-bar openings, and the free ingress of air to the ashpit, which, once adjusted, the equable and economic working of the furnace would be secured. Unfortunately however, for the cause of economy of fuel, the reverse is the case; not only are the requirements of the furnace not uniform, but they fluctuate within very wide limits, whilst the evil results in waste of fuel which ensue, are aggravated by the fact that the furnace's unassisted power of supplying itself, *varies in an inverse ratio* to its requirements, being least when these are greatest.

Assume a coaling interval of 15 minutes, and that towards its end the carburetted hydrogen having passed off, a layer of ignited carbon alone is left on the bars through which the current of air has gradually worn for itself a series of channels or perforations, till their united area is more than sufficient to admit the right quantity of air under the existing amount of draft. Let us then examine the condition of the same furnace a few minutes later, after the act of coaling has taken place, and we shall find a thicker layer of fuel on the bars, the channels for the passage of air which previously existed in the thinner layer, obliterated, and the temperature of the furnace greatly lowered by the abstraction of heat consequent upon the introduction of the charge of cold fuel, and the volatilization of its gas going forward. Thus the diminished temperature in the stack diminishes the draft at the period when the resistance offered by the fuel to the passage of air is greatest, and the demands of the furnace for air is at its highest point, in consequence of the large quantity of oxygen required for the ignition of the carburetted hydrogen gas now in course of rapid evolution. As the necessary sequel to these conditions, the gas generated passes

off unburnt, worse than simply wasted, because it has abstracted a portion of heat from the ignited carbon in undergoing transformation into the gaseous form. We here get an explanation of the fact that more heat is practically obtained in some kinds of furnaces from coke, or, in other words, coal deprived of $\frac{1}{3}$rd part by weight of that portion of its combustible matter which is richest in heating material, than from coal in its pure state. From the same cause also, viz., defective furnace management, the commercial value of coal is often in an inverse ratio to the quantity of its bituminous constituents and heat-giving power, were proper means employed to make them practically available.

In short, under the present system of furnace management, the function of the furnace as an agent for raising steam may be said to be almost entirely suspended after each coaling interval, and only gradually regained, the furnace virtually assuming the office of a retort for the manufacture of gas, but with this difference in the result, that the gas which in the latter case is carefully preserved as a valuable commodity, is here despatched unconsumed up the chimney, carrying off at the same time the heat stolen from the carbon in effecting its volatilization.

Can a doubt be entertained of the wisdom and desirability of burning this gas instead of wasting it—of filling the furnace with flame instead of smoke—of causing the generation of steam to proceed with additional rapidity immediately after coaling, instead of being all but suspended?

Now all that is required to evoke this transformation is to supply the gas with ten times its own measure of atmospheric air, and (except in a few exceptional cases of badly constructed furnaces) it will require no further solicitation to burst into flame. Why is this not universally done? A curious chapter of human error is unfolded by the answer. When apertures of the necessary size to admit the requisite supply of air were arranged to open into the furnace above the fuel, notwithstanding the smoke and gases were converted into flame, it was found that the production of steam was diminished from 25 to 30 per cent., and only when there was sufficiently ample boiler power to allow of heavier firing, and burning from 25 to 30 per cent. more coal, could the previous supply of steam be obtained. The most extensive experience, and the most exact experiments, alike concur in establishing the accuracy of these figures.

The analysis we have made of the varying conditions of the furnace at different periods of the coaling interval, and of the sequence of chemical changes of which these varying conditions are productive, not only enables us to explain how, and why, this great diminution in the generation of steam occurs, but places us on a vantage ground of knowledge from which the necessity of such a result is foreseen. So dark, however, has been the pall of ignorance that has rested on the subject, in such mystery have the chemical operations of our furnaces been shrouded, that for half a century each year has seen the advent of some new scheme, identical with its predecessors in the folly of allowing a constant supply of air to enter the furnace above the fuel, but vainly pretending to elude the evil consequences inseparable from such a practice, by trivial alterations in non-essential details. Strange to say, the persistence of these evil results, after the *shape* of the orifices

for the admission of air had been changed from round to square, and from square to oblong; the *material* from firebrick to cast-iron, and from cast-iron to wrought; the *position* from the door to the bridge, and from the bridge to the flues; instead of opening the eyes of the experimenters to the common ground of failure inherent in all their attempts, caused them to adopt as an indisputable maxim the dogma "that smoke can only be burnt at the cost of fuel," a doctrine most correctly describing the result of the faulty expedients they resorted to for obtaining this object, but widely the reverse of truth when enunciated as a general law.

When a continuous stream of air is allowed to pass into the furnace above the fuel, about six times the required quantity of air enters and mingles with the products of combustion, and the great resulting waste of fuel, amounting to from 25 to 30 per cent., will be seen to be a necessary consequence, by all who have followed the exposition I have given of the great reduction in temperature inseparably attendant upon the entrance of a large surplus body of air into the furnace.

The fact is, the policy of admitting air above the fire, is governed by the very simple law that no more should be admitted than is required to furnish the quota of oxygen necessary for the perfect oxydation of the gases rising from the fuel at the moment. The quantity required is greatest after coaling, gradually diminishes in amount throughout the space of about five or six minutes, and then ceases altogether, the increasing draft in the stack having become sufficient to supply through the grate bars the diminished and diminishing wants of the fuel.

To secure the entrance of the required amount of air and no more, to ensure that this supply shall vary in quantity *pari passu* with the wants of the fuel, that is to say be greatest after coaling, gradually diminish in amount throughout a space of about five or six minutes, and then cease altogether, it is indispensable that the regulation of the feed of air be placed under the control of automatic mechanism, which not only far surpasses in regularity as to time, and equability as to motion, the limits attainable by the utmost watchfulness of man, but is free from the liability to the omissions from negligence, inseparable from human superintendence, especially where, as in the present instance, that superintendence would be of an exceptionally monotonous and wearisome character, and carried on in an atmosphere most oppressive and exhausting.

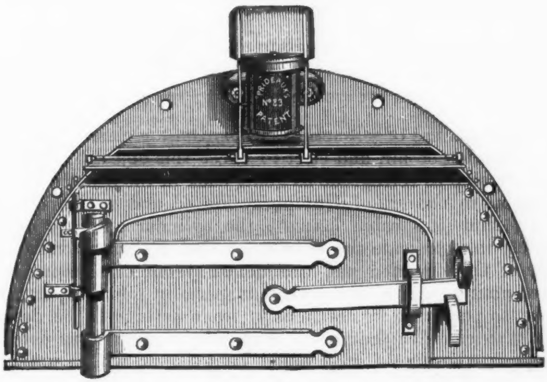
The front of every furnace should be supplied with air passages of an area equal to the admission of the largest required amount of air, and opening into the furnace by small perforations or grating for finely dividing and heating the air, but communicating exteriorly with one common mouth fitted with a valve closing automatically in any desired period of time. This valve is to be thrown wide open upon closing the door after coaling, when it immediately begins to close gradually, supplying the furnace with the great desideratum, a gradually diminishing feed of air throughout the five or six minutes' interval for which it is adjusted.

To illustrate my views on the subject in a practical form, I have placed before you on the table an apparatus which I consider fulfils the required conditions. Without admitting any superfluous air it converts

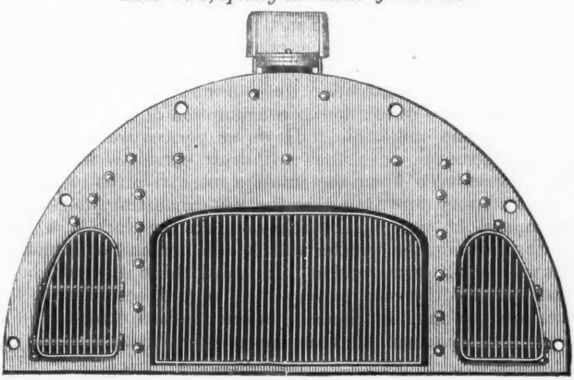
into flame the carburetted hydrogen rapidly evolved after coaling (and wasted under the present unintelligent system of furnace management, apparently as a matter of course). The economy resulting is from 8 to 10 per cent. with best Welsh, and from 16 to 24 per cent. with bituminous coal, and since the apparatus presents no objectionable feature to counterbalance these advantages, but on the contrary increases the steam supply, diminishes the temperature of the stoke-hole, prevents smoke, and increases the durability of the sails, I venture to predict that, when the incredulity of ignorance as to possible saving of fuel, which now flourishes, becomes replaced by an intelligent insight into furnace operations, its use will become universal, and it will be regarded as being as indispensable an adjunct to the furnace, as the governor now is to the engine.

Prideaux's Fuel Economiser, or Automatic Apparatus for Regulating the Air-Supply of Furnaces.

Front View.



Back View, opening on interior of Furnace.



DIFFERENT SYSTEMS OF FURNACE MANAGEMENT COMPARED.

Systems.	Results.	Coal burnt.	
		Bituminous.	Welsh.
Old, and still prevailing. No air admitted above fire.	SMOKE. Hot furnace door.	100	90
Annually tried under a new alias for fifty years past, but always abandoned. Constant admission of air above fire.	NO SMOKE. Diminished steam supply.	130	110
Plan of the future. Air admitted and cut off by Automatic Air Regulator.	NO SMOKE. Increased steam supply. Cold furnace door.	80	80

To discard the use of self-acting mechanism for closing the apertures for the admission of air, and elect to effect this object by hand in preference, is a step as retrograde as going back in the construction of the steam-engine to the era of Humphrey Potter, and stationing a boy to open and shut the valve between the cylinder and the condenser. Adequately to appreciate the obtuseness and stolidity involved in the adoption of this oft-tried and abandoned system of shutting by hand, when self-acting mechanism invented specially for the purpose is in existence, so perfect in its action as to leave nothing to be desired, we have only to consider that, even supposing a man were detailed for the purpose, whose sole duty would be to stand with a watch in his hand to shut off the air supply at the right moment, twice the proper quantity of air would enter the furnace; whilst how hopeless of attainment is even an approximation to such a result, except in an experiment, all having any practical knowledge of stokers, stoking, and stoke-holes, can decide for themselves.

I will now draw your attention for a few moments to a subject by no means inoperative in relation to consumption of fuel, I allude to the temperature of the stoke-hole. However perfect we may make our furnace arrangements, we cannot withdraw ourselves from a certain amount of dependence upon the intelligence and attentiveness of our firemen. And very sure I am that the less exhausting we render their occupation, and the more comfortable we make the place in which they perform their duties, the greater will be the amount of attention the furnaces will be likely to receive. Indeed I think it would be to be regretted were it otherwise, so very little regard, according to my experience, does the humanitarian side of the question command. There cannot be two opinions but that far greater strain is made on the

physical energies of a fireman by working in a temperature of 120° than would be occasioned by performing the same duties in an atmosphere of 100°. In fact, the depression of the vital powers that ensues in tropical climates, where the heat of the stoke-hole often mounts up to 135°, is a fertile source of disease, and loss of life. Now experience authorises my saying that there is hardly a ship in Her Majesty's Navy in which the temperature of the stoke-hole might not easily be reduced from 20° to 30°.

The same apparatus which regulates the air-feed forms a most efficient agent for preventing the radiation of heat into the stoke-hole, from the fire door and front of the furnace, never becoming so hot but that you can place the back of your hand against it. As to the other great source of heat, the smoke-box doors, they should be fitted with what I have designated "non-conducting shields." These are made of tin, are light, easily applied, and productive of no inconvenience of any kind, and, at the same time, are so effective in resisting the passage of heat, that, in conjunction with the air-feeding apparatus, they cause the stoke-hole to be on the average at least 24° cooler.

As an advocate of the comfort of the fireman, I am glad to be able to adduce in support of my own opinion that of Staff Commander Balliston, of the "Elfin," who, in his official report, says, "I cannot "speak too highly of the smoke-box doors supplied for trial. They "are simple, and easily applied to all steam vessels, neither do I con-"sider them the least in the way, as they are fastened on to the pre-"sent doors, and can be taken down or put up at pleasure.

"I consider their merits are even better than the enclosed report of "the temperatures taken with the doors on now, and the correspond-"ing account of the temperature taken last year when they were not "supplied. My reason for saying so is, that, from the confined space "of the stoke-hole, the thermometer is obliged to be placed in a corner "out of the way of the stokers, where the heat must necessarily accu-"mulate. The patent doors are so cool that you may place your hand "upon them without feeling the least warmth; the same may also be "said of the front of the patent fire-door.

"The thermometer, when placed on the patent smoke-door, showed "92°; and when the door was taken down, and it was hung on the "flue-door, it immediately went up to 116°, thereby showing a differ-"ence in the temperature of 24°, and that in a place where the stokers "have to work."

My attention was first called to the great heat firemen are often subjected to in stoke-holes in the following manner:—My first experiment was made by permission of the Admiralty, at my own expense, in Portsmouth Dockyard. A thermometer with its bulb in contact with the face of my fire-door never marked more than 64°, whilst the adjoining door of the same marine boiler was sometimes red with heat. The contrast seemed to strike the Naval Officers who witnessed it as something marvellous. The first lieutenant of a steamer just returned from the West Indies observed to me, "Mr. Prideaux, your apparatus "will lead to a considerable saving of fuel. I don't mean by producing "more perfect combustion, which it *may* or may *not* do, for I have not

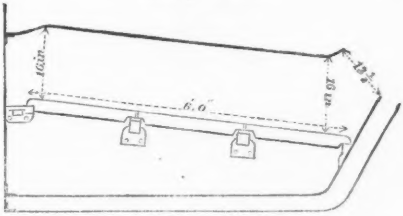
" tried it; but it will save fuel by enabling the men to tend the fires " with more comfort. My experience is, that a high temperature in " the furnace-room always tells its tale in the consumption of fuel; for " whatever people may think, careful stoking does not take place in an " atmosphere of 140°, and it is not in human nature that it should."

He also informed me that when commanding the "Bull Dog" in the Channel the summer before, he had had several instances of stokers fainting, and being obliged to be hoisted up on deck by tackle, to be revived by the fresh air. The thermometer in the stoke-hole indicated 140°, and the firemen could not handle their implements without binding cloths round the handles. It seemed to me monstrous that men should be tortured in this way if it could be prevented, and so I devised these non-conducting shields; and it should not be overlooked that, in addition to keeping down the heat of the stoke-hole, they prevent a waste of draft power. I determined from the first never to make an article of profit of them, and I have always offered to supply owners of steam vessels with them at cost price.

In treating of so important a question as the economic production of steam power within limits so inadequate to do justice to so extensive a subject, that some departments must necessarily be left comparatively in shadow, I have felt I should best consult your wishes to acquire, and mine to impart, useful information, by endeavouring to emphasize those points at present least understood and most neglected. In endeavouring to fulfil this intention, I find I have already occupied so much of your time on the right management of the furnace, that it will be impossible for me to advert in more than general terms to the structural details of the boiler and the engine. It must suffice to say, that in the past, attention has in the former, been directed too exclusively to the amount of grate, bar, and heating surface, to the comparative neglect of securing the due circulation of the water, and an adequate amount of what I have designated *flame space*, that is, a sufficient distance between the end of the bars, and the beginning of the tubes, to admit of the completion of the formation of flame before the products of combustion enter the latter.

If you take a piece of wire gauze, and insert it across the middle of the flame from a gas burner, or candle, you will find that the portion of the flame above the gauze becomes immediately extinguished. We have flame *below* the gauze but smoke *above*. The inflammable mixture of air and gas, which would otherwise form the upper portion of the flame, is cooled down by contact with the wire net work below the point of ignition. What the wire gauze does in the experiment with the flame of a gaslight, viz., prevent combustion by cooling the mixture of air and gas below the point of ignition, the surface of the boiler tubes (kept comparatively cool by contact with water) effect with the gases rising from the furnace, and hence waste of fuel takes place as a matter of necessity, where the distance from the end of the furnace bars to the beginning of the tubes, is not sufficient to admit of the completion of the development of the flame; the gases which otherwise would have formed flame, passing off as smoke, or being deposited as soot.

Fig. 1.
Scale $\frac{1}{3}''$ to foot.



A few days ago, sorting over some papers, I came on a tracing (Fig. 1) endorsed "order declined," which forcibly illustrates how little the necessity for a flame-space has been understood up to a comparatively recent period. It was sent to me by a firm on the Thames as a guide for making a set of my furnace doors for a steamer in process of building. I wrote back suggesting that 6 inches should be taken off the bars, and 6 inches added to the flue, and the crown of the furnace raised at the back, and stated that, notwithstanding the tubes would be shortened 6 inches, I would guarantee the furnace should make more steam, and burn a very much smaller quantity of coal. I was told in reply that they had been obliged to make the most of the limited space at their disposal, and requested to proceed with making the doors. This, however, I declined to do, assigning as a reason that the proportions of the boiler were so radically bad, that nothing but disappointment and discredit to all concerned could attend on its construction as designed.

Now in this case the prevalent faults in boiler construction are carried to such an extreme of badness that I doubt if any of you ever saw such a boiler at work, for it would fail so utterly in generating steam that I imagine, after a short trial, it would be thrown aside as worthless. You will observe there is absolutely no provision for a flame-space, and, as a necessary consequence, the heated gas coming at once in contact with the cold tubes, is cooled down below the point of ignition, and instead of forming flame to raise steam, produces soot to coat the tubes. The prevention of smoke in such a furnace is a physical impossibility and the waste of fuel enormous.

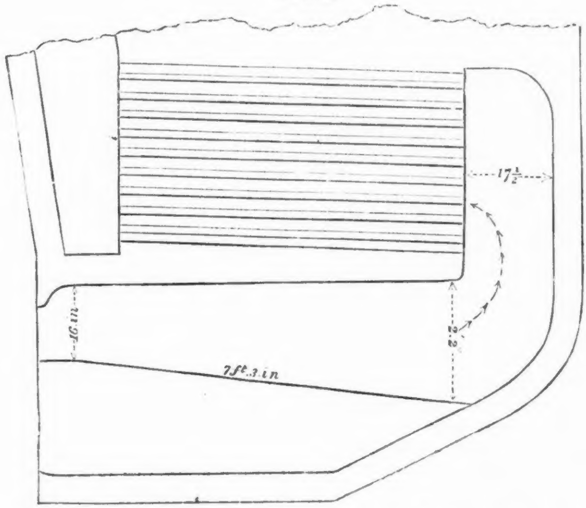
Fig. 2.

Fig. 2 is a sketch of the furnaces of H.M.S. "Princess Royal." This is a great advance upon the preceding, for this is a workable furnace. Nevertheless the prevalent faults above alluded to, are only diminished, not removed. The bars are too long, and the flame-space much too short and narrow, to obtain the best results even with Welsh coal, whilst were bituminous coal used, smoke, with its attendant great waste of fuel, would ensue, especially when steaming at full speed. Since a boiler with a flame-space of sufficient dimensions to allow of the inflammation of all the gas from bituminous coal, is perfectly well adapted to burn

Welsh coal, I think it is obvious that all the boilers for the Navy should be so constructed. In this case, even when supplied with all

Fig. 2.

1″ to foot.



bituminous coal, which must occasionally happen in time of war, smoke could always be prevented. I hardly know a subject on which so great and wide-spread a misapprehension exists, as that entertained with regard to furnaces making smoke. If the flame-space of a furnace be not sufficiently roomy to admit of the full development of the flame, the prevention of smoke is a physical impossibility, but if the flame-space be sufficient, nothing can be easier. A few holes in the door or bridge, or the furnace-door left ajar, are sufficient to prevent smoke. But such, or any mode of preventing smoke by the admission of a continuous supply of air above the fire, necessitates 30 per cent. more coal being burnt to obtain the same supply of steam. This it is which has imparted to the nuisance its vitality, and not the existence of any difficulty in the attainment of the object itself.

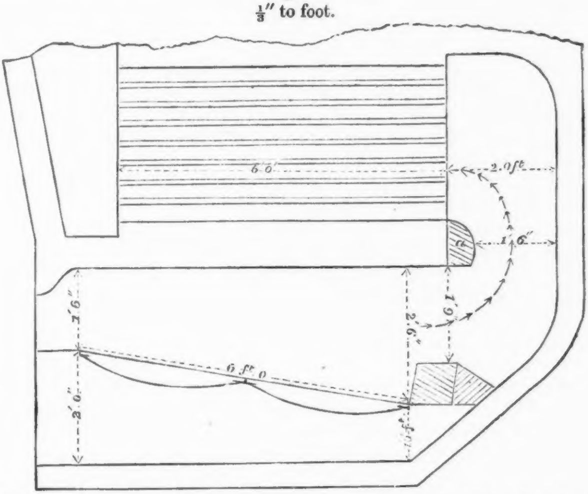
Fig. 3.

Fig. 3 embodies my views of what the proportions of the existing type of a naval boiler should be. You will observe it affords ample space for the full development of the flame of the most bituminous coal before the products of combustion reach the tubes, and it might be fed entirely with bituminous coal without an atom of smoke being visible, whilst it would give better results in regard to economy than any naval boiler of the kind it has been my lot to meet with. It possesses a novelty in a bridge (a) of firebrick which spans the flue,

with its under side level with the crown of the furnace. By preventing the current of heated gases taking so short a curve as would otherwise be the case, it materially contributes to their more equable diffusion through the tubes, remedying the fault at present complained

Fig. 3.

$\frac{1}{3}''$ to foot.



of, that the major portion passes through the lower tubes, leaving but little to find its way through the higher, which is in reality tantamount to a diminution of the heating surface.*

Before quitting the first branch of our enquiry, viz., "How to evaporate the greatest weight of water with a given weight of fuel hinging on the structural arrangements and management of the furnace and boiler," I am desirous of bringing prominently under your notice the fact, that since the office of the boiler (including the furnace) begins and ends with the evaporation of water, the proper way to test the work it performs, is *to measure the quantity of water it evaporates*, by fitting every boiler with a water meter, instead of estimating its duty in the very vague and unsatisfactory mode in use at present, viz., by the performance of the ship it serves to propel, thus subjecting the

* In 1857 I made an offer to the Admiralty to improve the furnaces of H.M.S. "Impérieuse," saying I could do so very inexpensively, whilst they could be restored to their previous form if thought desirable; that this would not likely be the case, as the alterations I should make would not be *experiments*, but founded on a knowledge of the subject, acquired by having for seven years past made the specialities of furnaces almost exclusively the object of my study, in addition to which, during the last two years I had had the experience of adopting my automatic furnace-door to 600 furnaces of the most varied character, adding, "whenever an opportunity is afforded me, I shall be happy to give the country the benefit of my long study and experience on this subject; and I unhesitatingly affirm, that boilers may be constructed greatly in advance of these at present used in the Navy."—T. S. P.

results to all the uncertainty inseparable from a variety of contingences such as defects in packing of pistons, in valves, in bearings, in condenser, or other portions of the engine, and the vicissitudes of winds, tides, currents, and sea, and the state of the ship's bottom, propeller, &c., &c., the effects being to import such an amount of uncertainty into the results, that the formation of positive conclusions and comparisons is rendered impossible.

In carrying out scientific experiments, the first thing considered is, how best to eliminate sources of error by securing as far as possible the existence of similar conditions during each experiment of a series, for thus only can reliable results be obtained. In their experiments on "Baxter's mixture," the Admiralty had put to sea in search of variable conditions, and after being at work in the "Lucifer" and "Urgent" for three years, had apparently failed to arrive at any useful or decisive conclusion. In fact, I do not suppose they have added one grain of positive knowledge to our previous stock. Now had they put to me in a definite form the question they wanted solved, I would have undertaken to have given them an answer in three weeks instead of three years, and one which no subsequent amount of experimenting would ever have invalidated. The probability, however, is, that I could have given them an answer without experimenting at all. As Naval Officers, what would you think of sending a gun to sea to test the accuracy of a new mode of rifling, and determine the target figure? Now to a chemist, testing the value of a fuel by the locomotive performance of a ship, which means measuring the results at the tail-end of a set of variable conditions, was equally absurd. It was lamentable to see such a want of intelligence exhibited in the conduct of public affairs, for it not only caused a great waste of money, but discredited the nation in the eyes of foreign states.

The first step to progress, or rather an indispensable preliminary to taking the first step, is an accurate knowledge of our existing position, and it always has been my opinion that what I cannot but regard as the present highly unsatisfactory amount of coal burnt, to power obtained, is greatly to be attributed to our habitually neglecting to determine by exact measurement, the actual work performed by the fuel in water evaporated. Many years ago I took considerable trouble to induce the Admiralty to fit the boilers of all Her Majesty's ships with "water-meters," and keep a record of the duty performed in weight of water evaporated, for coal expended, believing the adoption of such a system could not fail to be ultimately productive of a greatly increased economy of fuel, but my efforts were not successful.

In reviewing the present state of the question of economy of fuel as a whole, I confess the point which presents itself most forcibly to my mind, both from the waste it entails, and the degree in which its existence is overlooked, is the circumstance that in the management of our furnaces we make no provision for the widely different conditions as to air supply, which ought to prevail, as more or less time has elapsed after coaling, involving the more or less rapid evolution of gas, or coke alone remaining to undergo combustion.

The SECOND BRANCH of our subject, "How to obtain the maximum

mechanical effect from a given quantity of steam," dependent upon the construction and management of the engine, is, no doubt, a far more attractive subject for enquiry than furnace-management, and one which commands a far greater amount of attention, and on some future occasion I may perhaps have the pleasure of presenting you with some analysis of its details. For the present I must content myself with saying in general terms that a very general agreement now exists as to the channel through which increased economy is to be sought, viz., by increasing the extent to which the steam is used expansively, through employing steam of higher pressure, and applying heat to the surface of the cylinder. A great increase in economy has been effected by travelling on this road, and I cannot doubt but that it may be pursued still further with advantage. In my treatise on "Economy of Fuel," published in February, 1853, I gave an estimate of the theoretic capabilities of a steam-engine working at 90 lbs. pressure, and cutting off at one-sixth, with the exterior of the cylinder preserved at the same temperature as the boiler, observing "the time will come when it will be quite an exceptional case for an engine to be worked at a lower pressure, or at a lower grade of expansion than this, for the simple reason that there is nothing to prevent this degree being generally used, and, therefore, to employ less will be considered as sacrificing economy without an object." At this period the general pressure employed in the Navy was 10 lbs., whilst there was not a single steamer afloat provided with any appliance for applying heat to the cylinder.

Shortly after a consultation was held by desire of the Admiralty, at which it was decided that a considerable increase, I think to 26 lbs., should take place, and I was informed by a gentleman present that my book, which had then just appeared, was quoted in support of the opinion that a much higher pressure might be adopted with perfect safety and great advantage.

From that period to this the pressure has gradually crept up till from 45 to 50, and even 60 lbs. pressure is now not unfrequently used in marine boilers, and I am quite satisfied this progressive advance will continue till the pressure of 90 lbs. is reached, for the simple reason as I then stated, "that there is nothing to prevent this pressure being generally used, and, therefore, to employ less will be looked upon as sacrificing economy without an object."

I do not believe, however, that we shall rest at 90 lbs. Other conditions being equal, the higher the pressure the greater the economy, but as we mount upwards in pressure, certain impediments, certain drawbacks present themselves. Now locomotive engineers being shut out from the advantages of condensation, have had every inducement to increase their pressure till some barrier was encountered which rendered further advance no longer advantageous, and I find they have settled down to working with from 120 lbs. to 140 lbs. on the guage, or, in other words, using steam of from 9 to $10\frac{1}{3}$ atmospheres, and I have no doubt but that in marine engines we shall ultimately come to much the same practice. Could I afford the luxury of a steam yacht, I should certainly arrange to work with steam of 9 atmospheres, and cut off at $\frac{1}{10}$, and by combining with this degree of pressure and expansion in-

creased economy of fuel by the use of my automatic apparatus for regulating the air supply, I should expect to attain an economy of about 1 lb. of coal per indicated horse-power per hour. If I live a few years longer, I believe I shall see this degree of economy realised, and I do not hesitate to give the opinion that when we have arrived at this point, we shall have nearly reached the utmost limits which the nature of the subject renders practically attainable.

Lightness and simplicity of working parts powerfully contribute to economy of fuel, and I think we are justified in expecting to see great advances made in the future in these directions.

Here is a small model of an engine of novel construction which I have recently met with, which appears to me to offer peculiar advantages in many points for marine use, and which, if I am not greatly mistaken, has a future before it. Half the cases of steam ships breaking down arise from either the crank or the connecting-rod breaking. This engine dispenses with both. The speciality which first attracted my attention as marking it as peculiarly adapted for marine use, is its economy of space. It requires only five-eighths the space of the shortest connecting-rod engine, whilst in regard to friction I think it will compare advantageously with the trunk engine.

I am also assured, on testimony on which I can rely, that its average weight and average cost will not exceed five-eighths of that of marine engines of the ordinary form. An engine of the kind, of 20 horse-power, has now been in constant work night and day for two years pumping the water for a paper mill in the vicinity of London without once requiring repair.

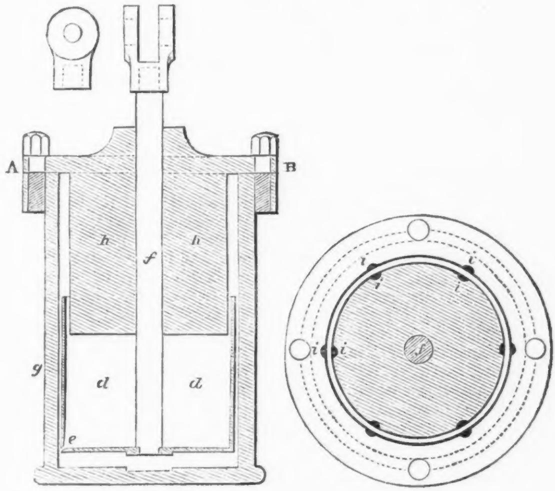
Besides lending the model for exhibition this evening, the proprietor has kindly given me permission to invite any gentleman interested in the subject to see the pumping engine at work.

There is one phase of the question of economy of fuel on which I have not touched, viz., that concerned with husbanding the resources of the steam-power at command; on what occasions slow speed should be used, and on what the use of steam-power dispensed with altogether. But these are questions of seamanship on which it would be presumptous in me to offer you advice, and if not presumptous, superfluous, since the subject has been most ably handled by a gallant Officer whom I have the pleasure of seeing here to-night, Admiral Ryder, in a book well deserving of being more widely known.

The CHAIRMAN: Is yours a self-acting apparatus to admit the air?

Mr. PRIDEAUX: I daresay the Members of this Institution are aware that I have been at work at this subject for a very long period. This drawing represents the first apparatus that I had for self-closing. This is a water cylinder which is fitted with a vulcanised cap of india-rubber. This piston is the same kind of piston as is used in the hydraulic press. You may move it up rapidly, because the india-rubber side collapses and allows the water to pass. When it is up, the india-rubber expands by the pressure, and it can only pass down as the water below travels through this small aperture (the size of which is regulated by a screw), and comes over the top. The only defect in this apparatus was, that it wanted to be filled with water every day. When it was filled every day the india-rubber piston lasted, on an average, nine months. In fact, it just amounted to this, that when the engineer took an interest in the thing, it was easily kept in working order. In the "Argus," under Captain Grandy, it worked exceedingly well. Sulphur is used in

the preparation of vulcanised india-rubber, and I had a few cases where some peculiarity in the water induced chemical action, and crystals of sulphate of copper were deposited; but the occurrence was rare. There is no doubt that this new apparatus is a considerable improvement upon the water cylinder. It entirely dispenses with any superintendence; it does not require any filling up.



The cistern, *d*, being filled with mercury and placed at the bottom of the cylinder, *g*, upon raising the cistern, the cylindrical plunger, *h*, enters the cistern, causing the mercury to flow over its sides and pass through the grooves, *i*, to the bottom of the cylinder. The raising of the cylinder rod lifts and opens the air-valve, when the weight of the flap, slightly depressing the cistern, causes the mercury to rise in the grooves and round the sides of the cylinder considerably above the level of the bottom of the cistern, and, as a consequence, to flow into the cistern through the small orifice, *e*, causing it gradually to descend and the air-valve to close in a time proportioned to the size of the orifice and the area of the cistern. This apparatus will work from an hour to a minute. That is set for six minutes, which is about the average time for a marine furnace. I have had this apparatus working six months in a stokehole, without any cap over it. You observe it is capped like the works of a watch, so as to prevent any dust getting into it. I feel very confident it would work throughout the three years of a ship's commission without once requiring adjustment. In fact, I see no reason why it should not work for twenty years.

The CHAIRMAN: When you open the furnace-door, it opens the valve-box, and after you shut the door, the apparatus gradually shuts itself, and cuts off the supply of air.

Mr. PRIDEAUX: Shuts itself in any time that it may be regulated for. Marine furnaces would be from five to six minutes. The cistern contains 5 lbs. of quicksilver.

Captain BURGESS: What is the cost of that apparatus, including the fitting of it?

Mr. PRIDEAUX: A single one is about £20; if there are several of one size they come to less.

Captain HOSEASON: What is the royalty to an engineer?

Mr. Prideaux: That includes royalty and everything,—the entire cost.*

The Chairman: I think you will all agree with me that this is a most important subject that Mr. Prideaux has lectured upon. I think no engineer or naval man can differ as to the great importance of some apparatus for consuming smoke. The only question, it appears to me, is what is the best plan for accomplishing the object. Mr. Prideaux has explained very clearly, both in his lecture and by his diagrams, that there would be a very great saving in the consumption of fuel according to his plan; and I have not the slightest doubt about it, as long as this apparatus works properly, and the door is kept clear of dust and dirt. The only thing that puzzles me is, that the plan has been before the Admiralty so very long, and they have not adopted it. But that does not at all imply that it is not the right plan. We all know that the Admiralty very often take up plans which, in my opinion, they ought not to take up, and cast aside plans which they ought to take up. According to what I understand, the plan for consuming smoke that they have adopted is the plan of Mr. Murdoch, a naval engineer. It acts upon a different principle from that of Mr. Prideaux; instead of a current of air over the top of the fire, it admits the current of air at the back of the bridge; and it equally consumes the smoke. But this (Mr. Prideaux's) apparatus does not interfere with the size or proportions of the furnace at all. I suppose every engineer when he makes his engine calculates the size of his fireplace, and that everything is most correctly proportioned. If you take his (Mr. Murdoch's) furnace, and cut off one-fifth from the end of it, supposing it is calculated to burn a certain quantity of coal, you diminish his power of producing steam. Therefore, if all the fireplaces in the Navy are to be altered on Mr. Murdoch's plan, and this plan of Mr. Prideaux's would answer equally well, without the necessity of making any alteration in the furnaces, I think it would be preferable to adopt it. I hope some gentleman will give us his opinion on the subject.

Admiral Wellesley, C.B.: If I am not trespassing too soon, there is one point with regard to this subject which Mr. Prideaux might explain. It is with reference to these self-acting doors. If I understand rightly, when that door is open the quicksilver is pumped up, or whatever the process may be, and as long as the door is open, nothing takes place. But the moment the door is shut, the valve begins to act, and then five minutes must elapse before it has gone down again. Supposing the engineer to walk along his stokehole, and that he wants to have a look at his fires as he goes along, in order to see that his people are doing their work properly, he throws all his doors open each time, and consequently the moment he opens the fire door the quicksilver is pumped up again, the valve is raised, and the process is all gone through again needlessly. Then, again, it is no novelty admitting the air over the top of the fire-place. It has been done by our engineers for themselves; they have been in the habit of perforating the front door; but the difficulty they had was that the holes were always there. As I understand it, the merit of this plan is that it is a self-acting apparatus. It would be so if you were always to fill your furnace by means of it, and let the fire remain thirteen or fourteen minutes. But that will not do for a naval engineer, who wants to be going along, constantly, looking at his fires and having his doors open. As I understand, every time that door is open, the valve is raised again, and it requires five or six minutes to close the valve. I only want to know whether the engineer can disconnect it in any way.

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* With regard to the question of price, I am desirous of observing—

1st. That the dimensions of the air-passages in each furnace-door and front are a matter of calculation, each having to be constructed with reference to the furnace for which the door and front is designed.

2nd. That the workmanship requires to be of the best character, and great solidity, to maintain the apparatus in working order, amidst the dirt and heat of the stoke-hole from one year's end to another, without requiring even cleaning, a desideratum attained for the first time, in the present apparatus.

3rd. That, on an average, the price charged, is repayed by the saving of fuel in three months.

4th. That I have always offered to accept six months' saving of fuel, as payment for the apparatus.

Mr. PRIDEAUX: You need not make the air valve self-opening. It is perfectly easy to make it the duty of the fireman to open the valve after coaling. Then of course it would not open of itself with the opening of the door. But if the engineer opens the door to look at the fire, when he shuts the door he has only got to close the valve down at once. You cannot have it both ways. Holes that are always open admit about six times as large an air supply as this apparatus.

Admiral WELLESLEY: Supposing the engineer should wish to look at his fires before it is time to coal, then by opening the door he opens the air-feed.

Mr. PRIDEAUX: At first I did not make it self-opening, but only self-closing, maintaining that you ought to have firemen sufficiently intelligent to understand and remember that when they shut the door after coaling they had to lift this air valve up, and then it would shut itself. But we find that our customers generally prefer to have them self-opening as well as self-closing; but you can shut the air valve down close at any moment if desired.*

Admiral WELLESLEY: Exactly; that meets my question.

Admiral RYDER: You spoke of the tin shields.

Mr. PRIDEAUX: What I call a non-conducting shield. They are closed air chambers of tin. Air is an exceedingly bad conductor of heat. These shields are screwed on to the flue doors. They are very slight and easily taken off.

Rear-Admiral RYDER: Mr. Prideaux has kindly alluded to a work of mine on "Economy of Fuel," long out of print, published some twenty years ago, which touched upon various parts of this subject that he has not alluded to. The subject is a very wide one. I am sure it could not be discussed properly to-night; I doubt if it could be discussed in less than two or three nights. "Economy of fuel" includes many branches; I will run over a few of them, very shortly, to show what a large subject it is, and what a great deal there is in it. The particular branch of the subject dwelt upon by the Lecturer, viz., the introduction of air into the furnace, is very important, and his doors appear to meet the difficulty. After considering the title of the paper in all its width, one may fairly say that the question each naval Officer would naturally have asked himself before coming here to-night was, what part of this very large subject, "How can the economy of coal be best promoted in "the Navy," is to be considered by Mr. Prideaux to-night. We now know, thanks to the most interesting and instructive paper read by Mr. Prideaux. Well, but let us take the broadest part of this very wide subject first, viz., the question as it must be considered at head quarters. At once we find ourselves face to face with that moot question, What is the most *suitable* and most *economical* kind of fuel to be supplied to ships of war, and are the terms convertible? This is a very large subject with which naval Officers in command of ships have practically nothing to do, for we must take what coal is given to us, and make the best we can of it. Another very important question relates to depôts of coal abroad. This bears also, like the preceding, upon economy in the *gross* sum expended upon coal yearly. The necessity of our having numerous fortified depôts for coal, the coal being covered and not kept too long, was touched upon in a very interesting paper read last year by Captain Hoseason, R.N. This, again, is a very large subject, and a most important one, which would take a long time to discuss. We have all heard a great deal lately of the question of the "mixed coal" which is now supplied to the Navy. I hope we shall soon have some some facts from the Admiralty detailing the experiments which have been tried across the Mediterranean, and comparing the economical merits of Welsh coal with those of the Admiralty mixture, and of north country coal by itself. I believe, from what I have heard, it will be shown that Welsh coal is very much more economical in all respects, even to the extent of 20 per cent., than the "mixture." At the same time there is this to be said on the other side, and it must not be forgotten, viz., that the Welsh coal, if stowed in the tropics, is said to deteriorate sooner, owing to its friability (not to any chemical change) than all other kinds of coal. It is well, therefore, that our furnaces should be fitted, if possible, so as to

* In point of fact, however, opening the door a little to look at the fire hardly opens the valve at all; only when the door is thrown wide open, as for firing, is the valve widely opened.

burn Welsh coal well and economically, and also to burn well and economically other kinds of coal, if, indeed, we can have furnaces so fitted. If we cannot, then I agree with Lord Lauderdale we had better have our furnaces fitted to burn, at all events, well and economically the Welsh coal that we shall endeavour to supply our ships with in war. Experiments on the relative merits of different descriptions of coal under all circumstances should be commenced at once.

The CHAIRMAN: We must first be satisfied that the north country coal does keep better in a hot climate than the Welsh. I entirely dispute that.

Admiral RYDER: Perhaps you may be right, but I only say it has been stated so. The person who gave me the information was Rear-Admiral Sir William Mends, who has had a great deal to do with coal depôts for troop-ships. The information he gave me was in print, and professed to be a report on the deterioration of coal *abroad*. These are two of the points which occur to me as forming the broadest part of the subject.

When we are treating of the economy of fuel in the Navy, we at once see the importance of our having the most economical engines and boilers in the ships, economical as regards the consumption of fuel, as well as of wear and tear. The Committee of Designs, of which I was a member, received much evidence on this point a few months since, and satisfied themselves that the compound engine is by far the most economical engine that we can have, and that the pressure on the boiler is being increased year by year. The compound engine will burn a less quantity of coal per indicated horse-power than any other, approaching to 1 lb. per indicated horse-power per hour. The expansion gear should cut off as early as one-twentieth of the stroke, and the ports should be much increased in size. Having got our engine and boiler on board, and the ship in our hands, the question, of course, presents itself, what is the most economical way of managing the fuel when you have got it on board? There is no doubt about it that the more you can use sail, and the less you rely upon coal, simply *quâ* economy, the better. It is then a very important question to what extent should our ships be masted, and to what extent should they have engines? This is a large question, indeed, and it would take a very long time to discuss. I am of opinion that no ship-of-war, except vessels for *harbour* defence only, should be without a sail equipment sufficient at least to make them manageable in a gale of wind, and aid them in making passages, and that the majority of our men-of-war should be fully rigged, and so constructed that they should be able to beat to windward under all plain sail in smooth water more than one mile an hour.

In the next place there is the most important question of working steam *expansively*, which I am sure Captain Hoseason will allude to presently, as he can speak on it with more weight than I can. It is a question which ought to interest all naval Officers, and which I am afraid is often overlooked by those of them before whom it has not been properly brought. I have, when taking passages in ships-of-war, been startled to see how little the expansion valves of the engines were considered or used with judgment, and how often ships were burning a great deal more coal than they ought, simply because the steam was not used as expansively as it ought to be. This, also, is a very large question which would take a long time to discuss. There is another matter germane to it which has often occurred to me, and especially when I was last afloat. I communicated with the Admiralty upon the subject, and they desired me to draw up a draft circular on Economy of Fuel. A part of this circular was adopted.* The point I raised was this:—I think it will be admitted by everybody, when they consider the subject, that always in ships without masts, and frequently in masted ships, with foul wind or calms, steam must be used, but that if there is no particular object in reaching your port on a particular day, the most economical speed for the *voyage* will be, *cœteris paribus*, that which will cause the

* Since this paper was read, another Circular has been issued, dated April 26th, 1872, adopting the recommendations made by me to their Lordships three years since, viz., that the speed which was the most economical *per mile* should be ascertained at the earliest opportunity in every ship, in calm weather, should be reported to their Lordships, and be always maintained under ordinary circumstances.

least consumption of fuel "per mile" (you must always carefully distinguish between "per mile" and "per hour"), and which will be either under sail alone, *if* there is no urgency whatever in the orders, or else some definite speed to be ascertained by experiment. Now the most economical speed under steam "per voyage" and per mile, is probably to go as *slowly* as possible. Of course it is, I hear some one say. But though everybody says "of course it is," they don't practice it. You will rarely find when you are cruizing that the vessel is going *as slow as possible*, and if you suggest that she should only go three and a-half or four knots, you would probably not be believed, and it would often be considered an absurdity by the Captain that he should be expected to reduce speed to three and a-half knots in a ship that can go fifteen. I do not say this is the universal feeling, but I know there is such a feeling. Officers have thought that no one has any right to hint even at their going less than seven or eight knots under steam alone, but lately, I believe, some ironclads have reduced their speed to two and a-half knots—so I have been told, and have seen in reports. When there is no object in going any quicker, the slowest speed is, as a rule, in light winds, or calms, and smooth water, the most economical speed per mile, on account of the resistance varying as the square of the speed, or nearly so. Of course we must look at both sides of the question. There is a speed in some engines which racks the engine, and causes backlash, to which the engines must not be reduced, and which although it might be the most economical speed, might injure the engine; this you have to guard against. But Officers in command should not speculate as to what is the most economical speed per mile when the breeze has freshened, or a sea got up, they should always ascertain it. If they take a little pains they can do so, and it will vary with the conditions of sea and wind which are happening at the time. Having determined what is the most economical speed per mile, they should maintain it. Of course they can proceed more quickly at any time, if there is reason for it. This is a very important point connected with "economy of fuel." Captains should always be asking themselves day by day, and hour by hour, whether they are steaming at the most economical speed *per mile*, and if not why not? One of the questions which came on the other day before the Committee on Designs (the report is on the table of the House of Commons, and no longer confidential) was this—In our large ships we have enormous engines of 1,200 horses nominal, working up to 7,000 indicated horse-power. If, as I maintain is true, the slowest possible speed is, under ordinary circumstances, the most economical per mile, and therefore per voyage, or when cruizing, then we are led up to this consideration, viz., that we have enormous engines with great friction, requiring constant supply of lubricating material, which must, somehow or other, be always driven along, even when we only want to maintain a speed of say three or four knots. Just as if a man, when driving his one horse coal cart, insisted on fastening all his stud to it, and dragging them after it. It is evident that there will be considerable loss in driving this monster, while we only want to maintain this speed of say 3 knots, and for which 200 or 300 indicated horse-power might be sufficient. Therefore, a suggestion was made, that in designing the engines for these large ships a small portion of (probably the after part of) the engine, say one-eighth, or 150 nominal horse power, should be capable of being disconnected from the rest of the engine, and be used for all ordinary occasions, viz., when you want the ship to go as slow as possible, and, therefore, as economically as possible. The Chief Engineer of the Admiralty, Mr. Wright, admitted that this would be an economical proceeding. Economy of fuel in war time will be everything, it will tend to ensure success.

The CHAIRMAN: I should say with two and a-half knots you will never get to the end of the voyage. Give us a half speed of ten knots.

Admiral RYDER: Ten knots is, I admit, a very *comfortable* speed, so is that of the express train; but it may be a ruinously extravagant speed, even in a fifteen knot steamer. Of course, if coal were not an object, it is the speed one would prefer to any slower. I have crossed the Atlantic in a steam line-of-battle-ship (the "Hero") at a speed purposely reduced throughout the voyage to from three to four knots, in light head winds and calms, when had I attempted to go faster, I should not have reached my port (Bermuda) for weeks. There is another question with regard to "economy of fuel," which came before us, very prominently, which is alluded to in the Com-

mittee's Report, and is also advanced I see in the Annual just published by the Professors and others of the School of Naval Architecture, Kensington, viz., that the "turbine" promises, when thoroughly developed, to be a very economical propeller, perhaps the most economical. It is much to be hoped that the Admiralty will now take steps to carry out most thorough experiments with regard to the turbine. This is the unanimous recommendation of the Committee on Designs, one of the few important points on which they were unanimous. There is an impression abroad that the turbine must be a less economical propeller than the screw: but the writer of the article referred to speaks of it, as at all events theoretically, the most economical of the two. Its numerous other advantages are manifest, and have often been pointed out here. I have suggested to the Admiralty that to promote "economy of fuel" at sea, when under steam, an entry should be made every day by the Captain in the log at noon, and oftener if necessary, replying to the following questions: 1. What speed are you maintaining? 2. What fuel are you spending per mile? 3. What speed would be most economical in fuel per mile at this particular time, either as estimated or ascertained, by diagram? 4. If you are not proceeding at the speed which is the most economical per mile, why not? If this were ordered to be done, and Commanding Officers had every day to make that little confession, as it were, to their Commander-in-Chief and the Admiralty, I am sure that a very remarkable reduction in the total consumption of fuel throughout the Service would take place: because when a man had to answer these questions daily, it would often puzzle him to find and to give any sufficient reason why he was not steaming as economically per mile, which is per voyage, as he might. He would thus be led gently, but by an irresistibly persuasive power, to practise the utmost economy, not a senseless economy, imperilling the ship, but a wise and judicious economy. An order to the above effect would also tell upon the senior Officers, commanding fleets and squadrons; and they would certainly adopt the plan of more fully explaining than at present to the Captain in their sailing orders, either the urgency or non-urgency of the orders, or state the day beyond which it was not desirable their voyage should be extended.

The indicator diagram, that invaluable aid to the Captain, as well as to the engineer, tells us by the "terminal pressure" what is the relative "consumption of fuel" per "revolution," and therefore per mile, when the speeds compared are not widely different. Suppose that the speed has been maintained in a calm at the slowest speed possible, without backlash or racking, say 2·5 knots, and that that speed has been ascertained by aid of the diagram to be, in a calm and smooth water, the most economical per mile. The wind freshens to a steady breeze ahead, and the revolutions (say 20) which drove the ship 2·5 knots in the calm cease to drive her ahead more than 1 knot. The 20 revolutions must evidently be increased, but by how much? The experiment should be conducted in this way:—Increase the revolutions by say two or three at a time, using the expansion gear of course, ascertaining the speed, and taking a diagram at each increase of revolutions. Then the

$$\frac{\text{No. of revolutions} \times \text{terminal pressure in tenths of inches}}{\text{Knots of speed}}$$

will give a comparative measure of the consumption of coal per mile at each speed, and the fraction which yields the smallest quotient will have as the speed involved in it the most economical speed per mile for those circumstances of wind and sea.*

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* *Example.*—The breeze having freshened ahead, the number of revolutions (20) which had previously driven the ship 2·5 knots now only drives her 1 knot, increase the revolutions successively to say 23, 26, 29, 32, 35, and let the mean terminal pressures on both sides of the piston be 10, 11, 12, 13, 14, 15, and the speeds 1, 2, 2·8, 3·4, 3·8, 4·1, then as—

$$(1)\ \frac{20 \times 10}{1} = 200.$$

$$(2)\ \frac{23 \times 11}{2} = 126.$$

Steaming against a current, the most economical speed is approximately half as fast again as the current. If current 4 knots, speed through the water should be 6 knots, over the bottom, 2 knots. As I said at the commencement of my remarks, the title of the paper is so *wide* that I have been seduced into greater discursiveness than I intended. I wish Mr. Prideaux all success.

Captain Hoseason, R.N.: As my friend, Admiral Ryder, has alluded to me in his observations, especially as to that economy of fuel that is derived from the expansive action of steam, I hope I may be able to say a few words which will, I trust, be a course of consolation to the lecturer. He has told us how many years he has treated upon this all important subject, the economy of fuel, and for what a lengthened period he has been engaged in endeavouring to push forward his invention, and that he has encountered little more than a passive resistance at the hands of the Lords of the Admiralty. Yet we all agree that the abatement of the smoke nuisance is one of vital importance both as regards efficiency and economy in steamers. There is no want of lucidity in the lecturer, therefore if those at the fountain head do not see their way clearly, it cannot be from want of having the facts placed clearly before them.

I also have been a labourer in the same vineyard with himself. It was in the year 1842, I first brought my views of the economy of fuel to be derived from a still further development of the expansion of steam before the Admiralty, and in the year 1872 I find the subject but little understood and still less cared for.

The Lords of the Admiralty caused the following letter to be written to me, dated 19th July, 1842:—"I am commanded by my Lords Commissioners of the Admiralty "to return you their thanks for your communication on the subject of using steam "expansively, and to send you the accompanying copy of a memorandum they are "about to issue on the subject to the Commanding Officers of all Her Majesty's "steamers."

They sent me the memorandum in question without ever having consulted me as to its composition, and when I came to peruse it, I found it drawn up in such English, and so unscientific, that I felt myself in duty bound in respect for my own reputation, to fully analyse their Lordships' Circular, which will be found contained in the pamphlet I hold in my hand, and which I here present to the Institution.

The lecturer in introducing this paper has, as Admiral Ryder states, opened up a very large and important question, which is daily growing in importance, seeing that our Naval and mercantile steam fleets are now nearly entirely composed of vessels whose primary power is steam. And I have only to regret that we should be called upon to discuss off hand so large and difficult a subject, and with our time, after having the paper read, so much restricted.

The Chairman: I think you will all agree with me that we ought to thank Mr. Prideaux for the very interesting lecture he has given us. I only wish we had more time to work out the subject, and that he would expand it to greater length. There would be more questions put upon the subject, because when a subject is

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$$(3)\ \frac{26 \times 12}{2\cdot8} = 112.$$

$$(4)\ \frac{29 \times 13}{3\cdot4} = 111 \text{ (the minimum quotient).}$$

$$(5)\ \frac{32 \times 14}{3\cdot8} = 118.$$

$$(6)\ \frac{35 \times 15}{4\cdot1} = 128.$$

No. 4, viz., 29 revolutions, giving a speed of 3·4 knots, appears to be the most economical speed per mile, as 111 is the minimum quotient. This case is given merely in illustration, and does not profess to be a *bonâ fide* experiment. If time admits, the actual expenditure of fuel per mile should of course be ascertained.

brought before a meeting of this sort, and only partially discussed, very little good results. There is no doubt of the necessity for consuming smoke, but the question is whether or not the smoke can be consumed. Mr. Prideaux contends that by his plan there is a gain of fuel; many engineers contend that the smoke cannot be consumed without a loss of fuel. There is a wonderful difference between the two. It would be of great importance if the question could be worked out and discussed. Perhaps Mr. Prideaux would answer any observations that have been made.

Mr. Prideaux: I think that what fell from Admiral Ryder and Captain Hoseason hardly related to the particular department of economy of fuel which I have treated on to-night. With regard to what your Lordship said, I would just observe that the distinctive difference between Mr. Murdoch's plan and this plan is, not so much the part of the furnace in which the air is admitted, though that is a considerable point. There is no doubt that it is more injurious to admit a continual supply of air above the fuel at the bridge than it is at the door. But the distinctive difference between the two plans is this, that Mr. Murdoch's, if it is to be called Mr. Murdoch's, is one of the old plans in which the shutting off is left to human agency. I maintain that that is never to be relied upon, and that it is impossible by this means to regulate the air-feed correctly, because if you had a man to stand with a watch in his hand, to shut it off at the expiration of five or six minutes, which you would never get a man to do, even then twice the right quantity of air would enter the furnace. It has been tried over and over again, and it has always been abandoned. When I heard the Admiralty were trying to burn "Baxter's mixture" on such a system, I predicted from the first that they would never accomplish it. But if they had had this automatic apparatus, they might have burned the coal very well. I have proved it in vessels that were burning all Newcastle coal. I tried it in the "Elfin." For two hours Admiral Denman and myself steamed through the fleet at Spithead at full speed. So copious was the steam supply, that we had only three fires lighted out of four, and I do not think at 100 yards' distance anybody could have told from the top of the funnel that there was a fire on board the ship. It was all Newcastle coal. On the deck of the ship, as each shovel full was thrown on, you could see a trace of dust; but the moment the door was shut, it was all clear. No alteration was made to the furnace bars; the only alteration made was the substitution of my door for the common door. It certainly proved that Newcastle coal could be burned without smoke, in the ordinary marine boiler of the "Elfin."

Admiral Ryder: Do you say that the burning on that occasion was more economical than if you had Welsh coal with your door?

Mr. Prideaux: I believe Newcastle coal with this door will answer as well as Welsh coal.

Admiral Ryder: The door in use in both cases?

Mr. Prideaux: I think the result is about the same. Certainly, with a mixture of half Newcastle and half Welsh, if the furnace was fitted with one of these doors, you would not see any smoke from one month's end to another, and you would have a great economy of fuel; and, certainly, an increased quantity of steam.

Evening Meeting.

Monday, February 19th, 1872.

REAR-ADMIRAL A. P. RYDER, in the Chair.

NAMES of MEMBERS who joined the Institution between the 6th and 19th February, 1872.

LIFE.

Lyons, T. C., Col. late 87th Regt.
Baillie, Hugh S., Lieut. late R.N.
McLaughlin, Charles, Lieut., R.N.
Hewitt, Allen James, Lieut., Queen's Westr. Rifle Volrs.
Scrivener, H. B., Lieut., Queen's Westr. Rifle Volrs.

ANNUAL.

Kennett, V. H. Barrington, Lieut., Royal Elthorne Mil.
Daunt, Arthur H., Lieut., 2nd N. Durham Mil.
Baillie, F. H., Lieut., 60th Royal Rifles.
Richmond, H. T., Major, Staff Officer of Pensioners.
Templer, C. B., Lieut., late Indian Navy.
Maude, F. F., V.C., C.B., Col. late 3rd Buffs.
Berkeley, Robert, Captain, 29th Regt.
Colville, Hon. W. J., Col. late Rifle Brigade.
Hamilton, Mark, Esq., M.D., B.A., Surgeon, R.N.
Gray, William, M.P., Lt.-Col., 27th Lancashire Rifle Volrs.
Stewart, Hon. R. H., Capt. late 42nd Highlanders.
Troyte, Charles A. W., Major, 1st Devon Rifle Volrs.
Briggs, David, Lt.-Col., Bengal Staff Corps.
Chapman, J. F., Capt., 7th Dragoon Gds.
Toler, James O., Lieut., 74th Highlanders.
Simpson, Charles H., Lieut., 74th Highlanders.
Cureton, E. B., Col.-Commandant, Canterbury.
Harran, Edward, Capt., 4th Drag. Gds.

NAVAL GUNS.

By Commander WM. DAWSON, R.N.

. . . "instrument to plague the sons of men
For sin, on war and mutual slaughter bent."
MILTON.

UNDER many conditions of battle, as ships are at present equipped, the stem, whether employed to run into high-sided or to run over low freeboard vessels, would occupy the foremost position. But artillery would even then fulfil an important, if subordinate part. There are, however, many conditions of maritime war in which these positions would be reversed, and many others in which the result must be decided exclusively by artillery. Should offensive torpedoes be introduced as an essential portion of future naval armaments in all classes of ships, it will become so mutually dangerous for vessels to approach each other for ramming or over-riding, that the guns may be expected to resume their old position as the principal arbiters of naval combats. In whatever light, then, we regard the newer and more annihilating weapons, it will be seen that, for many most important purposes of maritime war, there is ample room for the fullest development of artillery science. Pitched battles between ships and guns of precisely the same type cannot be regarded otherwise than as most

exceptional; and it is most unlikely that special types of vessels will generally be at the right spot to do the particular work for which they were designed. Even in fleet actions, who shall say that the varying classes of ships will always be distinguishable, or will single one another out for attack; and that the wooden ship shall not run over the low freeboard monitor, the iron clad be pitched into by the gun vessel, &c., &c.? It seems then undesirable that the offensive powers of individual ships should be limited to those necessary for penetrating the least vulnerable parts of similar vessels. There is, in short, no necessary relation between the armour and the armament of given ships. Most ironclads, for example, are seriously damageable, if not destructible, outside their armour plating, and that by non-plate piercing weapons. Bombardments may be very effectively aided by non-plate piercing guns. Gunboats and torpedo vessels, which may destroy the stoutest ironclads, are themselves destructible by similar "light" artillery.

A consideration of the manifold uses to which ships of war may be applied, and of the many vulnerable points in hostile ironclads, leads me to doubt the wisdom of reducing their offensive powers to that of a few heavy plate-piercing ordnance. In our recent constructions many destructible portions have been lopped off, in that respect strengthening the defence, but increasing materially the danger of being over-ridden and leaving no space for carrying non-plate piercing guns. The defensive qualities gained by the removal of the topsides, appear to be compensated by the increased liability to be over-ridden; whilst the offensive power is greatly reduced by the impossibility of carrying "light" artillery outside the armour plating.

In the admirable paper on "the Attack and Defence of Fleets," by Captain P. H. Colomb, R.N., in No. 64, Vol. xv., of the Journal of this Institution, the experimental gun-practice made by the "Hercules," "Captain," and "Monarch," at a rock off Vigo, as well as the prize firing of a ship in the Channel squadron, is carefully analyzed; the former Flag Captain of that squadron, Captain J. G. Goodenough, R.N., concurring in the analysis. In that paper, Captain Colomb points out that the artillery powers of modern ships have decreased immensely as against similar vessels, as compared with that of the old wooden ships against the vessels of that period; and that this decrease of effective gun-power is proceeding rapidly with every improvement of the art of defence. Summing up his investigation of almost the only recorded practical naval gunnery experiment bearing on this point, Captain Colomb concludes, that "in six minutes from the opening "of the 'Monarch's' fire on the sister ship at 1,000 yards, she "will have fired 12 shot, of which one will have hit and another "may have glanced, and it remains an even chance whether the single "hit will have penetrated the enemy's armour." A single hit, the penetration of which is doubtful, is all that one of our most powerful ironclads can effect in the six minutes which a similar ship would be under fire whilst running down to ram or torpedo. Captain Colomb complains, with much reason, of the absence of exact corroborative experiment, or, if such exists, on the secrecy with which it is withheld

from the service, as to the number of useful hits to be anticipated in an artillery combat between moving vessels. He points out the fallacy of trusting to observations taken from the masthead, or from the extremes of the vessel firing, and the absolute necessity for experiments being exactly recorded by observers nearly at right angles to the range, if any reliance is to be placed on the record. In determining the absolute values of rifled armaments, we are, in the absence of such exact information, reasoning without premises. If we are to believe the reports of artillery fire at sea, with lively motion and at unknown distances, as made by observers in the same ship, it is far more accurate than that which takes place from an immovable platform, at well ascertained distances, by accomplished gunners at Shoeburyness. The publication of such absurdities might lead to more correct modes of observation.

As to mere rapidity of fire, when aim is not required at a small or moving object, and no alteration of step is required, each of the "Monarch's" four 25-ton turret guns can fire one round every 2′ 10″. A recent experiment was made, in firing four rounds, with battering charge and shot, at widely different distances:

1st. Horizontal, on centre step.
2nd. 3° depression, on top step.
3rd. $14\frac{1}{2}$ elevation, on lowest step.
4th. Horizontal, on centre step.

The intervals of time between the shots were:—

	3rd gun.	4th gun.	5th gun.	6th gun.
2nd round	2′ 40″	3′ 20″	3′ 0″	3′ 20″
3rd „	2 26	2 40	3 10	2 10
4th „	2 34	2 35	2 45	2 30
Total time	7 40	8 35	8 55	8 0

The training, elevating, compressing, and hydraulic-arrangements seem to be all that can be desired for 25-ton turret guns; their smooth and regular action contributing largely to accuracy. But the arrangements for ascertaining the distance, and for loading, are susceptible of great improvement.

Recent Australian newspapers gave very loose records of two days' shooting by the low freeboard breastwork monitor "Cerberus," a colonial defence ship of the new construction mounting four 10-inch 18-ton turret guns. Eleven shells were fired in two days' deliberate shooting at unknown distances supposed to vary from 2,500 to 3,700 yards. Of these, three were supposed by those on board to have fallen near the target,—how near, it was, of course, impossible to observe,—and only one burst. As no observations were taken at right angles to the range, there are no means of knowing whether the "Cerberus" (one of our most recent constructions) would have made a single hit at a penetrating angle during her two days' shooting. But, so far as the record goes, it shows

that the practice of the "Hercules," "Captain," and "Monarch," on which Captain Colomb relies, was conducted under exceptionally favourable conditions, as to knowledge of distance and as to skilful gunners. One effective shot out of twelve is then all that may be expected, even from a ship with masts from which to measure the distance, and in cool shooting at a fixed object of her own size. How all important, then, that this one projectile should strike end on, penetrate the armour, and explode a capacious bursting charge! If this one hitting shell break up before reaching the object; or, wabble along the bore, or fly "noisily" through the air, and then go flop, broadside on, against the hostile ship, twelve discharges would be thrown away for every such mishap; and thus for twelve minutes the "Monarch," with her four 25-ton guns, or the "Devastation," with her four 35-ton guns, though firing most rapidly, and making a great noise and much smoke, would be most helplessly inoffensive. Similarly the "Glatton," with her two 25-ton guns, would, by such a break up or "noisy" flight of the one hitting projectile in twelve, be reduced, not to silence, but to inoffensiveness for twenty-four minutes; and the "Hotspur," though of 2,637 tons, with her one 25-ton gun, would be harmless for 48 minutes. Surely, then, there is great need to cultivate in naval gunnery a scientific exactitude of observation, of record, of practice, and of study which has hitherto been foreign to the profession. It is only by such close research into details, practical and theoretical, that we can hope to discover the means of securing a larger percentage of hits, followed by useful penetration. That illiterate impatience of exact science which has in all ages distinguished the so-called "old school," ought to be set aside, now that scientific appliances permeate every part of the seaman's art, and ships are not only propelled but steered by steam and hydraulics; guns handled by beautiful hydraulic and other machinery, and fired by electricity; economical navigation assisted by meteorological studies, and ignorance no longer regarded as the essential handmaid of seamanship. Whether it is possible to secure better results from our heavy ordnance is worthy of careful investigation:—1st. As to shell not breaking up prematurely. 2nd. As to their not wabbling in the bore, making a puffing "noise" in their flight, and striking broadside-on instead of end-on. 3rd. As to improving the shooting by a better system of sighting and by greater attention to rapidly ascertaining and communicating the ever-varying distance.

Three Classes of Naval Guns.

Naval guns may be divided into three classes:—

(*a.*) *Small or Boat Guns*, of which there are about nine natures, some breech, some muzzle-loaders, some smooth-bore, some rifled, some of wrought iron, some of steel, and some of brass. All the rifles are grooved with an uniform spiral, those for the breech-loaders being multigroove with lead-coated projectiles, and the muzzle-loaders having three deep wide "Woolwich" grooves for two rings of studs. Of these, the breech loader offers many advantages for working in the confined space of the bow of a boat, though as military men prefer muzzle-loaders for field pieces, our newest boat guns are of this nature. The superior accuracy

which rifled guns afford when fired from a steady platform at known ranges is quite thrown away when firing from the lively bow of a pitching boat at unknown distances. This inaccuracy is greatly increased as regards the Armstrong breech-loaders, by the extremely small distance between the rear sight and fore sight, which renders a finely-graduated tangent-sight valueless. Muzzle-sights have been, however, restored in the new muzzle-loaders, and if some means were practised for ascertaining the distance, the shooting would be greatly improved. The essential importance for sea practice of a long radius between the sights may be illustrated by the trunnion sights of the 20-pr. 13-cwt. breechloader—a visual error of half an inch vertical when firing at an object 1,000 yards distant, would make about 300 yards difference in the range, whereas, by substituting a muzzle-sight, it would make about one-half or 150 yards. The length of 1° on the tangent-sight is about two-tenths of an inch for every foot of radius between the sights. The bearing which additional length of degrees on the tangent-scale has upon shooting is not evident when aiming from a steady rest with the eye close to the rear-sight; but the more lively the platform, and the further the eye is from the rear-sight, the more essential does it become to reduce the effect of unpreventible visual errors. Every foot gained between the sights admits of an additional ·2 inch of vertical visual error without any increase of inaccuracy in the shooting. This applies with equal force to all guns on shipboard, most of which would give one or two feet increased radius, *i.e.*, two-tenths or four-tenths of an inch compensation for visual errors, without interfering with the ports. All refinements of rifling, or of graduations in sights for increased accuracy, sink into insignificance when shooting with lively motion at sea, before this large preventible source of error.

(*b*.) "*Light*" *Guns*.—Second, comes the class of "light" guns, including nineteen varieties under six tons weight, most of which are ready to follow the numerous other obsolete weapons of similar weight which have been removed from the effective list. Some of these are wrought iron guns, of the Armstrong breech-loading pattern, about the disposal of which there is some difficulty. Others, however, like the cast iron 68-pr. of 95 cwt., the 8-inch gun of 65 cwt., and the 32-prs. of 56 cwt. and 58 cwt., cannot be parted from without a pang. Their best friends can hardly regard with satisfaction their conversion, at great expense, into rifled ordnance, by reaming them up, thus weakening their breeches, and inserting wrought-iron tubes of doubtful longitudinal strength.* By this device we obtain 150 doubtful mixed cast and wrought-iron guns for the same money which would work them up into one hundred perfect wrought-iron guns of the most approved Fraser pattern. We want at least one "light" wrought-iron rifled gun of about four tons weight for general use; but it is most undesirable to multiply weights and calibres in this class. A uniform spiral and two rings of studs, with French (Woolwich) or "shunt" grooves, are used in all these light muzzle-loading guns. But no new guns are being rifled on the "Shunt" system, as the studs overrode the grooves, owing, in some degree, to the loose fit in the bore, except at the muzzle-nip.

* See Report of Ordnance Select Committee, dated 16 March, 1868, page 8

The Americans, who have a large stock of heavy smooth bores on hand, and are desirous of possessing rifled ordnance, do not contemplate the adoption of this system of conversion. The 23 Parrott guns, which, out of 42, blew their own muzzles off at the siege of Charleston, were of this compound material, the wrought iron being outside; and, though the bursting was no doubt accelerated by the increasing twist given to the grooving, as reported by General Gilmore, yet the Chief of the Ordnance Bureau reports to Congress, June, 1871, that "Cast "iron is not believed to be suitable for heavy rifled guns; other material "should be experimented with."

These guns are largely used in small vessels. They are badly mounted on primeval truck carriages which work by jerks, causing great inaccuracy, and employing as many men as the $12\frac{1}{2}$-ton guns.

(*c.*) "*Heavy*" *Guns.*—The third class, or "heavy" guns, consists of all ordnance above 6 tons weight, of which there are at least eight different natures. The contest between guns and armour has led from time to time, to such developments in the conditions of both, that we are fast getting into a mess of calibres and weights, calling for the elimination of already obsolete weapons from the effective list. This mess may be further heightened by the great number of varieties in the projectiles, so that the "heavy" ordnance may soon have to be sifted and reduced to three, or at most four natures, and the projectiles for each reduced from six to three, or at most four, kinds. As it is on the "heavy" guns that we must place our chief reliance in future artillery combats, it may be well to consider them more in detail.

Foreign Navies.—Before proceeding to discuss our own weapons, it may be interesting to glance at the heavy armament of foreign navies. With regard to the calibre of their naval guns, England and the United States stand first, but the 20-inch Navy 1,000 prs. of $44\frac{1}{2}$ tons with 100 lb. charges, of the latter country, are relatively so inferior in effect to the rifled guns of other states that hardly any comparison is possible between them. England, on the other hand, possesses in its 10-, 11-, and 12-inch muzzle-loaders, the makings of effective guns, which fire, with imperfect rotation, projectiles of 400, 530, 600, and 700 lbs. in weight, with charges of 70, 85, and 100 lbs. of powder. The heaviest French 10·8-inch gun fires a projectile of 475 lbs., for which a charge of 79 lbs. of powder is required. The heaviest Danish gun is an 11·24-inch muzzle-loader, with a projectile of 462 lbs., and a charge of 66 lbs. of powder; Denmark has also 9- and 10-inch muzzle-loaders, with projectiles of 311 and 400 lbs. Holland has only got so far as a 9-inch gun for its marine artillery. The heaviest Italian gun is a 10-inch muzzle-loader, with a projectile of 400 lbs. weight, and a charge of 60 lbs. of powder. Austria still retains her 8- and 9-inch guns. The German Navy intends to adopt 10·238 and 11·05-inch Krupp steel breech-loaders, with lead-coated projectiles of 411 and 513 lbs., and charges of 70 and 88 lbs. of powder respectively. At present, however, its heaviest guns are 8- and 9-inch breech-loaders. Russia has already adopted the 11-inch Krupp breech-loader. Sweden and Spain have as yet no heavier gun in their navy than a 9-inch breech-loader, with a projectile of 316 lbs., and a charge of 52 lbs. of powder. The Krupp steel breech-

loaders have been adopted by Germany, Russia, Belgium, and Austria; the latter State has also some Armstrong muzzle-loaders. The French breech-loading system has been adopted by France, Holland, Spain, and Sweden. In Sweden, however, the mode of construction is peculiar to the country, and the guns are made of cast-iron. The English Armstrong "Shunt," and the French or "Woolwich" muzzle-loaders have been introduced in the English, Italian, Danish, and (to a certain extent) Austrian Navies. Bronze guns of large calibre have not been adopted by any State, though experiments have been made with them in the North German Navy, and the "Arminius" was at one time armed with 8-inch guns of this material. As for the powder employed in heavy guns, the English "pebble" and "pellet" have hitherto only been used by England, Holland, and Italy. In the Russian, Belgian, and Austrian Navies "prismatic," and in the United States "Mammoth" powder is used; while all the other States still employ the ordinary powder. It is believed, however, that the French and Swedish Navies will shortly adopt the new kinds of English powder. The Committee on explosives state, May, 1871, that "the Russian 11-inch "breech-loading gun of 25 tons, fires a battering charge of 82 lbs. of "prismatic powder, giving a muzzle energy of 185 foot tons per inch "of the shot's circumference, whereas our 25-ton muzzle-loading guns "were only intended to fire battering charges of about 70 lbs. rifle "large grain, giving a muzzle energy represented by about 160 foot "tons per inch of shot's circumference." With 85 lbs. of pebble powder our 25-ton guns give a muzzle energy of 187 foot tons per inch of shot's circumference. No navy appears to have overcome the difficulties of working these ponderous weapons with perfect safety, uniformity, accuracy, and ease in a seaway, except our own, and those which have copied from us. Rodman and Ericcson have exhausted talent and ingenuity in resolving this problem for the United States, but though that country had many years' start of us in handling heavy guns, the Chief of the Ordnance Bureau states, in his last report, that "a large "sum is required for alterations in the 10- and 15-inch iron gun car-"riages," which have to be re-made. To Captain R. A. E. Scott, R.N.,'s ingenuity we owe it that 12-ton, 18-ton, and 25-ton guns are now being worked on broadsides and in turrets. Four men can work the 25-ton gun on the "Hotspur's" broadside, at sea.

Construction of "Heavy" Guns.

Cast-iron Guns.—As is well known, the Americans construct their large smooth-bore guns of cast-iron, in the manipulation of which material they have attained rare excellence; but their Chief of the Ordnance Bureau reports that "it is thought that a still further im-"provement may be made by a change in the treatment of the metal "in the furnace, and experiments with this object in view are now "progressing." He, moreover, agrees with us, that "cast iron is not "believed to be suitable for heavy rifled guns." Comparing guns of nearly similar weight, we find that the American 15-inch Rodman of $19\frac{1}{2}$ tons, firing a shell of 453 lbs. weight, containing 17 lbs. bursting charge, performs 62 foot-tons "work" per inch of the shot's circum-

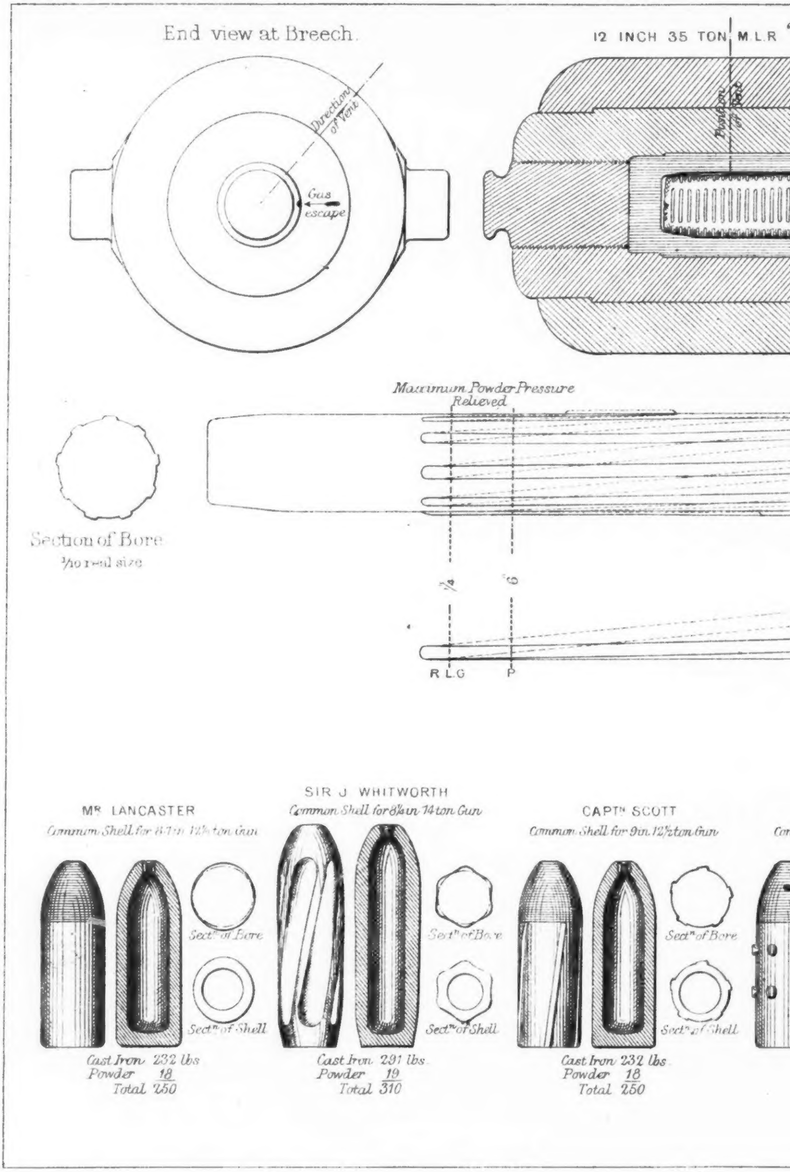
ference at 1,000 yards; whilst the English 10-inch 18-ton gun, firing a shell of 400 lbs. weight, containing $9\frac{1}{4}$ lbs. greater bursting charge, performs 61·3 foot tons more "work" per inch of circumference at the same distance. Taking then, the weight of gun, bursting charge of projectile, and "work" per inch of its circumference as a criterion, the English-built rifled guns have, at 1,000 yards range, greatly the advantage of the American cast-iron smooth-bore ones.

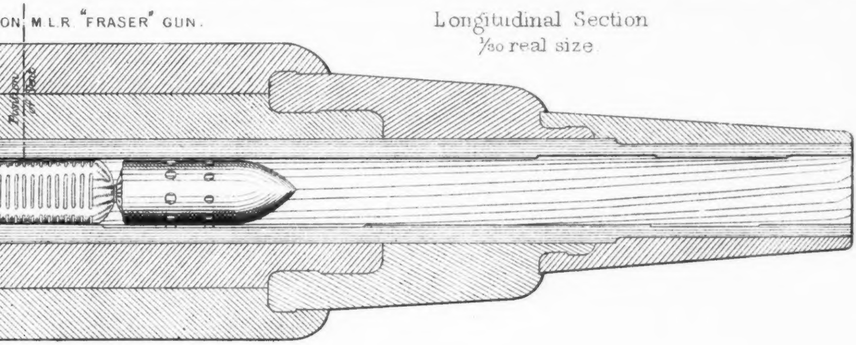
Steel Guns.—The only other material largely used in the manufacture of heavy ordnance, besides our own, is the Krupp steel. The Krupp guns are breechloaders, provided with lead-coated projectiles, squeezed through numerous grooves which are gradually reduced in size towards the muzzle sufficiently to make amends for the compression or wearing away of the lead coating in its progress along the bore. This ensures the perfect centering of the shot throughout the bore. Steel guns are more than double the cost of wrought-iron ones. Taken weight for weight, steel is generally stronger than wrought-iron; but in the block form it is subject to the uncertain endurances of all castings, and cannot be relied on for uniformity of strength, or for withstanding dynamic shocks. The limits of elasticity under static pressures, or that at which, if exceeded, the metal would fail to resume its form; and the breaking weight per square inch, with good specimens as tested by the machine at the Royal Gun Factories, are:—

	Limits of elasticity per sq. inch.	Breaking weight per sq. inch.
Cast-iron	4 tons	10 tons.
Wrought iron across the fibre	Same as	above.
Wrought iron, in the direction of its fibre	12 tons.	25 tons.
Steel	13 ,,	31 ,,
Steel toughened in oil	30 ,,	45 ,,

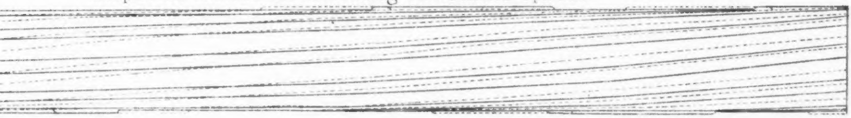
The brittle character of steel rendered its manufacture in blocks difficult when required to sustain dynamic shocks, but built guns have been more successful.

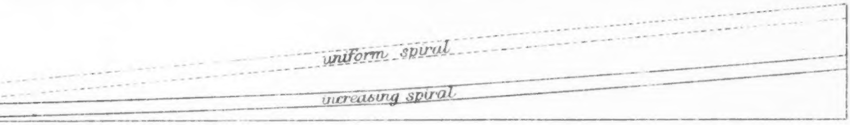
Moreover, when block steel guns do burst, they frequently do so explosively, dealing death and destruction to all around; whilst wrought iron guns generally, except when the shot jams, give timely warning of approaching dissolution. Thus, the jamming of shot and the violent bursts of wrought iron coil guns have, happily, not yet resulted in killing or wounding their friends, but we have detailed accounts of the bursting of 24 block steel guns, four being attended with loss of life. Of these, six field guns burst on service during the Prusso-Austrian campaign; another killed three Prussian cadets; another killed the Director of Prussian Artillery and a gunner; whilst the naval part of the suicidal fatality is represented by a 9-inch gun, which, bursting whilst at target practice on board the Russian frigate "Alexandra Nwsgi," killed twelve officers and men, wounded thirty, and seriously damaged the ship. Such a calamity would assuredly decide the fate of any seriously contested naval action. We have no account of any failures during the late Franco-German war.

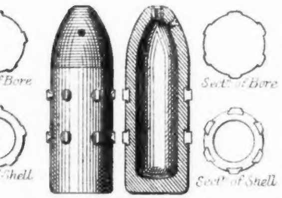

End view at Breech.
Direction of Vent
Gas escape
12 INCH 35 TON M.L.R
Position of Vent
Maximum Powder Pressure Relieved
Section of Bore
1/10 real size
R.L.G
P
MR LANCASTER
Common Shell for 8.7 in. 12¼ ton Gun
Sectn of Bore
Sectn of Shell
Cast Iron 232 lbs
Powder 18
Total 250
SIR J. WHITWORTH
Common Shell for 8¼ in. 14 ton Gun
Sectn of Bore
Sectn of Shell
Cast Iron 291 lbs.
Powder 19
Total 310
CAPTN SCOTT
Common Shell for 9 in. 12½ ton Gun
Sectn of Bore
Sectn of Shell
Cast Iron 232 lbs.
Powder 18
Total 250



Comparison between the increasing and uniform Spirals







System Rifling in bearing; Shot passing out	Calibre	Number of Grooves	Width of Grooves	Depth of Grooves	Metal removed pr. foot of Bore
					lbs.
"LANCASTER" 12th real size 	8·705"	2	8·705"	·328"	15·66
"WHITWORTH" 1/3 real size 	8·25"	6	3·3"	·4"	16·9
"SCOTT" 1/3 real size 	9"	5	·8"	·125"	1·39
"WOOLWICH" 1/3 real size 	9"	6	1·5	·18"	4·9

J. Jobbins

Block Steel Guns burst.

Date.		No. of guns.	Calibre.	Nature of steel.	Rounds.	Place.	Men killed.	Men wounded.
June, 1860	..	1	12 pr.	Mersey	6	Shoeburyness	—	—
June, 1861	..	1	VII in.	Mersey	16	Shoeburyness	—	—
Nov., 1861	..	1	20 pr.	Krupp	2	Shoeburyness	—	—
March, 1862	..	1	30 pr.	French	..	Gavres	—	—
April, 1863	..	1	20 pr.	Muskets	132	Shoeburyness	—	—
August, 1865	..	1	$9\frac{3}{4}$ in.	Krupp	..	Prussia	—	—
1864	..	1	$9\frac{1}{2}$ in.	Krupp	66	Russia	—	—
1865	..	1	$8\frac{1}{2}$ in.	Krupp	109	Russia	—	—
1866	..	2	Field	Krupp	..	Sadowa	—	—
1866	..	4	Field	Krupp	..	Prussian War	—	—
1866	..	1	Field	Krupp	..	Berlin	3 cadets	—
June, 1866	..	1	IX in.	Krupp	56	Russia	—	—
Jan., 1867	..	1	VII in.	Krupp	2	Woolwich	—	—
27 Sept., 1867	..	1	4 pr.	Krupp	..	Tegel, Berlin	2	—
July, 1867	..	1	IX in.	Krupp	..	Russian frigate, "Alexandra Nwsgi"	12	30
Nov., 1867	..	1	7·6 in.	French	..	Havre	1	—
1868	..	1	IX in.	Krupp	..	Russia	—	—
1868	..	1	IX in.	Krupp	..	Cadiz	—	—
Jan., 1869	..	1	VIII in.	Krupp	..	Prussia*	—	—
29 Sept., 1871	..	1	XI in.	Krupp, hooped	1	Cronstadt†	—	—

Were it not for the fatalities, these failures would not be remarkable, being less numerous than those of wrought iron guns destroyed by their own rifling. Nor do they affect the question of built or hooped steel guns. In the hooped steel gun which burst at Cronstadt, in 1871, it was the unhooped chase which gave way.

Wrought Iron Guns. (Plate XII.)—English guns are, as is generally known, built up of wrought iron coiled tubes, shrunk on over a steel inner tube, the general principle of which construction was originally introduced by Sir William Armstrong. Great improvements have been introduced into the system of manufacture under the auspices of the authorities of the Royal Gun Factories. Under Colonel Campbell's able guidance, Mr. R. S. Fraser, C.E., the Assistant Superintendent, has given great additional strength to guns:—1st, by the substitution of cheap, soft, scrap iron, of great tenacity, for that of an expensive hard iron, of great tensile strength, the latter property giving a brittle character, well calculated for the endurance of static pressures, but unequal to resist the dynamic forces, to meet which the more yielding soft iron is better designed; 2nd, by the reduction of the number of parts, and, therefore, of the number of welds and shrinkings in building the gun. Whilst the old construction consisted of fifteen to twenty-

* Into twenty pieces. † Into several pieces.

three parts, according to the calibre; the Fraser gun consists of four to six parts only. The Fraser coils are made of bars of greatly increased size proportioned to the weight of the gun, which are twisted one or two deep round a mandril (each riding turn breaking joint with the one below), and are then submitted to the hammer; 3rd, by changing the direction of the fibre in the breech piece, from that of a longitudinal forging of bars, to a transverse coil, adding greatly to the power to resist bursting strains around the powder-chamber. The steel tube is toughened in an oil bath, and is intended as a hard lining to receive the grooving, and, being less easily fused, to bear the erosion of the gas escaping from the powder-chamber, as well as to prevent the gas penetrating into imperfect welds, and to withstand the studs of the projectiles, which are found, when iron or bronze lining is used, to "upset" and bur the grooves rapidly and to bruize the bore so as to prevent, after a short time, the entrance of the shot.

The relative cost of the several constructions is :—

	£	
Cast iron guns	21	per ton.
Armstrong, wrought iron coils ..	100	..
Fraser, cheap iron	65	,,
Krupp's, or Whitworth's steel..	170	,,
Gun-metal	190	,,

The steel lining can be patched when slightly injured by its own projectiles; whilst it can be altogether replaced, at a cost of about £700 in the largest gun, when worn out or cracked by them. The cracking of the toughened steel lining does not necessarily disable the gun, so long as the shot can be entered. The injury is arrested when it reaches the wrought iron coil in which the strength of the gun resides. Thus, the 35-ton gun had its steel inner tube cracked in the lower groove near the seat of the lower stud, after firing about $3\frac{1}{2}$ tons of various gunpowders, with charges varying from 75 to 130 lbs., and 21 tons of projectiles, each weighing 700 lbs. The gun is still fit for work; whilst the Krupp steel 11-inch gun, which burst at Cronstadt on the 29th September last, at the first round, with 90·92 lbs. prismatic powder and 496·54 lbs. projectile, had its unhooped muzzle scattered into several pieces, the built part alone remaining on the carriage. The cost of the Krupp steel gun was £6,000, whilst that of a similar wrought iron one is about £2,500. The weak point of our present construction is the necessity for employing a steel lining. When the gun is heated by continuous heavy firing, an unequal expansion takes place, depriving the highly elastic oil-tempered steel lining of the intended support from the ductile wrought iron coils. There is great difficulty, however, in finding a better lining material which will withstand the concentration of rotary effort upon a small bearing, and which will not easily fuze or erode under the high temperature developed during the consumption of the charge, and which will yet expand simultaneously with the coils. The problem may be safely left to the untiring diligence and scientific talent displayed by the Director-General of Artillery and the manufacturing Superintendents at Wool-

wich, and other members of the Artillery Corps, to whose unsparing devotion and intelligent zeal, the country is deeply indebted for the high position its ordnance-manufacture has attained amongst all the civilized nations of the world.

Requirements in a Naval Gun.

In comparing different systems, it must be remembered that the elements of rifling are at least six in number, and admit of various combinations. The form of the bore; the form of the grooves; the number of grooves; the twist; the proportion of the weight of the elongated shot to that of a round ball of the same calibre, or, in other words, the calibre for a given weight of projectile, and the weight of projectile for a given calibre; the nature and arrangements of the studs, ribs, or other agency by which rotation is effected.

Colonel Owen, Professor of Artillery at Woolwich Academy, in his "*Modern Artillery*," classifies the conditions that are specially desirable in a system of rifling for military ordnance under five heads, of which the first is "accuracy of fire," and the last "to allow of the use of large charges," or endurance. We have no Professor of Artillery at the Naval College, as theoretical instruction does not form part of the naval gunnery course, but the late Director-General of Naval Ordnance has left on record a classification of six wants in a good naval gun, of which the first is endurance and the fifth accuracy; thus reversing the military classification. Both authorities are right. To the Army, extreme accuracy in the gun is most valuable, and can be realised in practice; whilst the breaking up of a projectile is only a nuisance, and the disabling of a gun a remediable evil. But to the Navy, the breaking up of a hitting shell may seriously affect the results of an action, and the disabling of a gun decide the engagement unfavourably; whilst, as to accuracy, Admiral Key says, "it is comparatively easy to "obtain it to such an extent, as is sufficient for purposes of naval war-"fare. Under the ordinary circumstances of a naval action, the pro-"bability of striking an enemy's ship, is dependent far more on an "accurate knowledge of the distance, on the steadiness of the ship "carrying the gun, and the skill of the man who fires it, than on the "qualities of the gun itself. Any of the systems of rifle ordnance "which have been tried with any degree of success, possess sufficient "accuracy for ordinary warfare. Indeed, it is highly probable that "the 100-pounder or 68-pounder smooth bore guns would strike the "enemy more frequently at 1,000 yards range and under, than the "most accurate rifled gun yet made, owing to the regularity of their "ricochet and low trajectory at short ranges." My experience confirms this, as I have found the 68-pounder, when used with a muzzle dispart, which doubles the radius for the tangent scale, shoot far better from a lively gunboat at 2,000 yards than rifled guns fired at the same time. The points which Admiral Key considers should take precedence of accuracy in a naval gun are enumerated by him in the order of their importance, thus:—

"1st. Strength (to withstand heavy charges), endurance, and regu-"larity of construction.

"2nd. Penetrating power, at ranges up to 1,200 yards. It is "certainly the most important under the existing circumstances of "naval warfare. It is the most difficult to obtain, and without it all "other qualities are useless.

"3rd. The use of a powerful shell.

"4th. Simplicity as regards non-liability to derangement and facility "of working. Of all systems, the muzzle-loading smooth bore has the "advantage on these points: the gun without grooves or any working "parts, the shot without studs, and of such a form that it will roll "home of itself. The Woolwich or Service system retains the dis- "advantages of a grooved gun and studded projectiles. Owing to the "great improvement in gun carriages," exclusively due to the mechanical genius of Captain R. A. E. Scott, R.N., the late Admiralty Superintendent of Naval Gun Carriages, "the 9-inch gun of $12\frac{1}{2}$ tons has "a great advantage in ease of handling over the 68-pounder of $4\frac{3}{4}$ tons, "being worked with fewer men, greater rapidity, and *far more security*;" a remark which applies now equally to the 18-ton, 25-ton, and 35-ton guns, all of which are mounted on Scott's broadside, turn-table, or turret carriages.

"5th. Accuracy, with a low trajectory, especially at ranges under "1,500 yards. The subordinate position occupied by the quality next "in order of importance, '*Accuracy*'" has already been explained.

"6th. Extensive range . . . for special purposes will prove of "considerable value; the circumstances under which the increase of "range will be found necessary will, however, be of rare occurrence. "This quality is, therefore, not a *necessity* for naval ordnance . . . "When, however, it is found that the great range of rifled guns is "combined with many other valuable qualities, it may be accepted as "an increase of efficiency which adds to their value."

Following the principles so admirably enunciated by the late Director-General of Naval Ordnance, I dismiss from present consideration such small differences as may exist between the various rifle systems in extent of range and in accuracy beyond 1,500 yards, and would direct attention to the four more essential points, as affecting:—

1st. The endurance of the gun and strength of the projectile.

2nd. Penetrating power up to 1,200 yards, as measured by the initial velocities of similar shot.

3rd. The use of a powerful shell.

4th. Simplicity as regards non-liability to derangement in the gun and in the projectile.

Many able artillery officers are dissatisfied with the present system of rifling, which was copied from the French. These experienced artillerymen point to the failure to rotate long-shell; to the breaking up of projectiles owing to the concentration of rotary effort on a small weakening ring of points; to the enormous loss of shell power in heavy guns; to the abrasions of the bore by the hammering action of the projectile; to the erosions of the upper portion of the bore aggravated by the deep wide grooves; and to the consequent lack of endurance of heavy guns and their projectiles, as well as to the irregular "noisy" flight of the latter; and they tell us that "a better system might be found."

*Four Systems of Rifling.**

Turning, then, to those systems of which official experience has been had at Shoeburyness, we find that lead-coated projectiles can only be employed in breech-loading ordnance.

Lead-expanding, as distinguished from lead-coated projectiles have proved unsuitable for heavy charges, the lead being blown off to the danger of friends, and the shots flying wild to the comfort of enemies. Of the various plans proposed for rifling muzzle-loading heavy ordnance, we have ample official experience of four which deserve attention. Three of these systems agree in employing but one material in the projectile; in providing a long iron bearing, co-extensive with its cylindrical length, which diffuses the strain caused by the effort of rotation over a great surface, and in adopting a uniform angle of groove which impresses rotary motion on the shot from its first movement in the bore. The fourth system employs compound material, one part of which is soft metal, easily bruised; a short bearing of six-tenths of an inch, being the flattened curve of a circular stud, in each groove; and an increasing twist, which does not attempt to impart rotation until the projectile has proceeded some distance along the bore and attained a high velocity.

The Lancaster Oval Bore. (Plate XII.)—Of the long-bearing, one-metal, uniform-spiral systems, Lancaster's two-groove or oval-bored system is first in order. Successfully adopted in small arms with lead bullets, it was introduced into the service for heavy ordnance in 1853, and was used during the Russian war, with an increasing spiral, which caused the bursting of three gun-muzzles out of eight. Sir Howard Douglas, in his "*Naval Gunnery*," says, "on one occasion the whole "muzzle was blown off by the *increasing strain* put upon it; but having "got rid of this weak part, the gun continued to be used with safety "and effect as a howitzer." A uniform spiral was subsequently used and good results were obtained from several guns at Shoeburyness, but notwithstanding Mr. Lancaster's great experience and talent, and the frequent experiments since made, eighteen years' labour have failed to attain perfect success. The last attempt was made in 1869, a 10-inch 18-ton gun being bored up with two wide grooves, each one-third of the circumference in width, the shoulders of the grooves being shaved off so as to form an oval bore. After five rounds "the experiment was "stopped, as it was evident that the shot failed to attain the necessary "rotation," and the gun was "made into a service gun." The Lancaster system, so successful in small arms, has so much to commend it for great guns, by the simplicity of its projectile, and in a manufacturing light, that its non-success is much to be regretted. Yet it is evident that by shaving off the shoulders of the grooves, two circular wedges are formed, tending to burst the gun; and accordingly in the report of the 7-inch gun competition, 1865, we are told that "The Lancaster shells, with only one exception, were

* As to past and foreign systems of ordnance and rifling, see Commander R. A. E. Scott, R.N.'s papers in the *Journal*, vol. v, No. 19, 1861; vol. vi, No. 21, 1862; vol. viii, No. 33, 1864; and Captain E. G. Fishbourne, R.N., C.B.'s papers, in vol. vi, No. 22, 1862; vol. viii, No. 30, 1864.

"found, on recovery, to be split in the head, showing apparently (as "has always been suspected) that in that system the projectile has a "great tendency to jam in the bore, bringing severe pressure both on "the gun and on the projectile." It was then "rejected on account "of the tendency to crush in the bore, evinced by the condition of the "recovered shells, its inferior accuracy (with shell), and the difficulty "of loading." To remedy these defects shewn in the 7-inch $7\frac{1}{2}$-ton gun, alterations of form were adopted in the 10-inch 18-ton gun, which, as we have already said, led to failure. The two circular wedges which form the oval bore, however suitable to lead bullets in small arms, bring too great a strain on both gun and projectile to admit of that system succeeding.

The Whitworth Polygonal System. (Plate XII.)—Sir Joseph Whitworth's system has been before the world for seventeen years, and had the advantage of the great ability, energy, and experience of that great mechanician. It was the first to pierce armour-plating, both with steel shot and with steel shell, and has been reported upon by twelve Committees acting under the authority of five Ministers of War, and been experimented upon by able officers in this and many other countries, without, however, being adopted for "heavy" guns by any except Brazil. It consists of a polygonal, flat-headed projectile, of small diameter, to be projected from a steel or compressed metal gun, with a rear-vent and patent cartridges. The system thus embraces many distinct points, each requiring independent investigation, and some of which appear to be valuable, whilst others have not been sufficiently tested. Little is authoritatively known of the value of metal compressed—when fluid—in withstanding powerful dynamical forces; though the late Director-General of Ordnance records that "The "Secretary of State saw $1\frac{1}{2}$ lbs of powder exploded in a closed cylinder "of $2\frac{1}{2}$ inches bore, by means of a touch-hole of ·1 inch. The steel "seemed to be about 3 inches thick, and the powder completely filled "the chamber." Thirty-one $1\frac{1}{2}$-lb. charges were exploded within this closed cylinder, with a total enlargement of ·1903 inch inside, and of ·0415 outside. A similar closed cylinder of cast iron burst into 30 fragments at the first explosion of 3 ozs. of powder, or one-eighth the charge used with compressed metal. And a similar cylinder of cast iron with wrought iron tube, like the converted 64-pounders, burst at the fourth explosion of 5, 6, 8, and 10 ozs. respectively, into 181 fragments, seven of which were of wrought iron. No similar comparison is recorded as having been made with ordinary steel or with projectiles. As the explosive power of a charge, as well as the inertia and friction of a projectile increase with their respective weights in a *cubical* ratio, whilst the surface of the chamber and of the base of the projectile, against which the force is exerted, increase only in a *square* ratio, the capability of compressed metal to withstand heavy explosions might be tested by its substitution for steel linings in a few heavy guns. The general principles with which we have now to do, are the polygonal rifling and the small bore. There can be little question that, other things being equal, the smaller the bore the better the penetration, so that if the one purpose to which guns were applied

in war was the perforation of unbacked iron targets with neat, clean little holes, a small bore should be adopted. But the Navy wants to destroy its foes, not to punch neat holes of minimum dimensions; and we ask for shells of large capacity, which, by sacrificing a little of the refinement of penetration, may do the maximum amount of damage upon ships of ordinary construction. The sacrifice of penetration in adopting the service bore is comparatively little, whilst the gain in destructive capacity, in ordinary cases, is great. It is a question of compromise, and we adopt a reasonable mean between the spherical smooth bore of the American, and the long, narrow bolt of Whitworth. Thus the last $8\frac{1}{4}$ inch steel built gun of Whitworth's tried at Shoeburyness in 1870, and which, after firing 148 rounds, slightly cracked a moveable circular disc placed at the bottom of the bore, was $14\frac{1}{2}$ tons weight, and threw a 310-lb. shot with a 40-lb. or 50-lb. charge. It is difficult to compare this with a 250-lb. projectile, thrown by a 43-lb. R.L.G. charge, from a 9-inch service gun of $12\frac{1}{2}$ tons weight.

Sir Joseph Whitworth himself says, "In my system, with its comparatively small bore and large powder charges, and my cartridge, the inner tube is no doubt severely tried. This is evidenced by the greatly increased range and power, for which we have no doubt to pay a high price in the shape of strain and wear upon the tube." Might he not sacrifice a little of range and accuracy, and bestow his attention to the other four points which Admiral Key enumerates as of greater importance? Why not apply the polygonal rifling in calibres similar to those at present in use?

The polygon has 24 surfaces, with six grooves, each ·4-inch deep, or three times the service depth, taking 16·9 lbs of metal per foot of bore out of the gun, weakening the gun in that proportion. Moreover, though the long iron bearing diffuses the strain over a large surface, and enables a rapid twist with great rotation to be given, yet the bearing is on a mere line in each groove and is much nearer the axis of the shot than in other systems, and the leverage for rotating is therefore much less. All iron-bearing systems rely on a mechanical fit, so that whatever advantage the polygonal system receives from Sir Joseph's great mechanical skill, can be equally imparted, under his leadership, to other iron-bearing systems.

The simplicity of material as to the shot in employing only one metal in its construction, and its incapability of injury by rough handling are such manifest advantages, that Sir Joseph Whitworth has always had the best wishes of many practical soldiers and sailors, who know the value of these qualities in the rough game of war. The late Director-General of Naval Ordnance classes the Whitworth system as first in point of "simplicity," as "the shot has no studs, and the gun no working parts;" whilst Sir Joseph says, "owing to the absence of studs, and to the simple form of my shot or shell, I am able now to fire them just as they leave the mould." "The cost of wages for grinding, drilling, punching, and finishing the large studded projectiles is many times greater than for those of the polygonal system; the cost of the metal for studs is also considerable."

Sir Joseph's argument is unanswerable when he says "For a 9-inch

"polygonal projectile, the rifled surfaces which both support and "rotate the shot, have an area of 187 inches." Whilst "the 12 studs "of the 9-inch Palliser projectile have a circumferential area of 18 "inches for supporting the shot, but the area of the sides of the six rear "studs, by which the rotary motion is given, is only 1·6 inch. No prac- "tical engineer would think of providing so small a surface to give even "a small amount of rotation to a body weighing 250 lbs., much less "when the rotation of the shot at the muzzle of the gun has to be at "the rate of about 2,400 revolutions per minute. The increasing "pitch, which has been adopted, prevents the use of more than one "stud in each groove for giving rotation. This varying the curve is "the worst possible mode of imparting rotation, for each rear stud can "only bear against the side of the groove of the gun on a line of its "surface, on account of the ever-varying curve, except by excessive "pressure, which jams and distorts the soft metal, and occasions "liability to accident. The greater the amount of windage, the greater "will be the liability to accident."

The long iron-bearing system is so manifestly right in principle, and the short soft-bearing one so evidently wrong, that the Whitworth means of applying the former is likely to be warmly advocated so long as the latter obtains.

The Scott centering strengthening flange. (Plate XII.)—The third long iron-bearing system, with one simple material in the projectile, and uniform spiral in the gun, is that of Captain R. A. E. Scott, R.N., a distinguished pupil of the "Excellent." This differs from the preceding two, and from the present service system, in that it takes much less strength out of the gun in cutting the grooves; adds, by its long iron-flanges, strengthening buttresses to the walls of the shell; centres the projectile in the bore so that the two axes correspond as when firing lead bullets; enables a shell of maximum capacity to be thrown; gives the greatest leverage for rotation from the centre of the shell to the extremity of the flange, and presents, in cross section, a deep bearing surface.

The advantages of this grooving, as to the gun, are that, whilst using the service calibre, it would have:—

1st. Few, narrow, shallow, rounded grooves, of the same size for all guns.

Three grooves for 9-ton guns and under; 5 grooves for 12- and 18-ton guns; and 7 grooves for 25-ton guns and upwards; as against 4, 6, 7, and 9 grooves respectively in the service guns. Width ·8 inch each groove, as against 1·5 inch in the service gun; making in the 25-ton guns a width of 5·6 inch surface removed instead of 13·5 inches.

The Ordnance Select Committee reported in 1863, of the 32-pounder gun thus rifled, that "the plan which leaves the largest portion of the "cylinder untouched will be the best" in firing round shot, and that the proportion of windage added to the spherical shot by the grooving in that gun, by the Lancaster system was 2·955 square inches; in the French (or Woolwich) gun 1·36 square inches; and by the Scott ·53 square inch. The depth of groove is ·125 inch, instead of ·18 to ·22 inch in the service guns. As the chief work is done on the driving

side of the groove, and not on the loading one, by dispensing with depth on the latter side, the gun is still less weakened, from two-thirds to three-fourths less metal being removed than with the service grooving.

The relative weakening effect on the gun by the several systems of grooving may, in one point of view, be estimated by a consideration of the amount of metal removed per foot of bore in the formation of the grooves. It will be seen that in the 9-inch gun, Scott removes less than one-third the quantity of metal removed by the "Woolwich" system. This difference increases in favour of Scott as the calibre increases.

System.	Calibre.	No. of grooves.	Width of groove.	Depth of groove.	Metal removed for grooving per foot of bore.
	inch.		inch.	inch.	lbs.
Whitworth	8·25 9·05	6	3·3	·4	16·9
Lancaster	8·705 9·361	2	8·705	·328	15·66
Woolwich	9	5	1·5	·18	4·9
Scott	9	5	·8	·125	1·39

2nd. By shallowing the loading side of the groove the flanges rest on inclined planes, so that the projectile, when forced into its seat, has a natural tendency to slip round so as to cling to or bite the driving side before the gun is fired, to start easily, and to mount into the centering position the moment it begins to move out.

3rd. The axis of the bore and of the shot coincide in small arms and in expanding bullets, as the whole cylindrical portion bears. But, with iron shot, a space occurs above the shot when in its seat, through which the explosive gases try to escape, eroding or excoriating the upper part of the bore, forcing down the base of the shot and acting unequally upon it. Scott introduced the system of giving less windage to the rifling projections on the shot, than to its body, so that the shot rests upon its projections and its body does not touch the bore at all. His rib or flange running along the whole cylindrical part of the shot and carried up to the base, almost fills up the groove at the base, and checks the escape of the gas with its consequent erosion of the bore and unequal action on the shot; whilst by striking the curve of the cross-section of the groove and of the rib with two different radii, the latter is driven up into the centre of the bore at once, causing the axis of the shot and of the bore to coincide as with a leaden bullet. The centrical rib thus secures the even motion of the projectile along the bore, as pointed out by Holley in his work on "Ordnance and Armour," and in former lectures in this Institution. Major Palliser, in his "Treatise on Compound Ordnance," states that "the principle of centering the "shot in the gun was originally pointed out by Commander Scott, "R.N."

4th. The centering rib whilst thus nearly filling up the groove at the base of the shot, lessens the escape of gas over the shot, diminishes the downward blow on its seat, and diffuses the effect of the blow by

receiving it upon a long rib instead of upon two studs $1\frac{1}{2}$ inches wide and $4\frac{1}{2}$ to 8 inches apart, the rear one of which is from $5\frac{2}{10}$ to $9\frac{1}{2}$ inches from the base. Erosion above and hammering below, are thus reduced.

Speaking of the present "Woolwich" system of rifling, Colonel Campbell, Royal Artillery, Superintendent of the Royal Gun Factories, states, 6th March, 1871, "that the scoring in the bores of heavy muzzle-"loading guns, due to the rush of gas over the projectile, is becoming "a matter for serious consideration, not so much as regards safety, but "as a point of economy, since the scoring arising from the use of "heavy charges wears out the tube locally, and involves the costly "operation of re-tubing the gun." This erosion is facilitated by wide deep grooves, and by the spaces in them between the studs.

5th. As to the projectile: the Ordnance Select Committee reported, 1863, that the centering iron-ribbed "projectiles have the merit of being "of convenient exterior form, easy to pile, but little liable to injury and "simple in manufacture;" and that this "form is the most advan-"tageous for a shell in respect to capacity." . . . "The Committee give "precedence, in respect to the efficiency of the projectile, to Commander "Scott," over seven other systems then tried, which included the present "Woolwich" or "French," the Armstrong "shunt," and the Lancaster. In 1865, the Committee reported that Scott's iron-ribbed shot cost £92 per thousand, and his shell £77 per thousand *less* than the "French" or "Woolwich" ones; whilst ten of his guns could be rifled in the same time as eight of the Woolwich ones at one-fifth less cost.

6th. The iron ribs which extend along the whole length of the cylindrical portion of the shell are cast with it, and impart strength to the walls. Moreover they diffuse the effort of rotation along its whole body and over the maximum length of the groove in the gun at a given instant: thus in the 7-inch double shell of $159\frac{1}{2}$ lbs. weight, the iron bearing would diffuse the strain over $3 \times 20{\cdot}5 = 61{\cdot}5$ inches, instead of concentrating the effort of rotation upon $3 \times {\cdot}6 = 1{\cdot}8$ inches, as at present. This shell is now balanced upon two studs equidistant from the centre of gravity, and 4·6 inches apart, the rear one, which does the work of rotation, being 9·55 inches from the base. Is it any wonder that it fails to rotate and topples over, and that the official work on "*Ammunition*," says "it is not contemplated to fire it at "long ranges, as its flight would be inaccurate, owing to its great "length;" whilst the Ordnance Select Committee report, "these shell "roll considerably owing to their great length and low velocity;" though great length does not prevent the long iron-bearing Whitworth shell receiving the necessary spin, even when five or six diameters long.

The principle of diffusing the effort of rotation over a large surface instead of concentrating it upon a small bearing is equally applicable to all calibres and projectiles, and is advantageous both to the steel lining of the gun and to the walls of the projectile, as is shown by the following Table; which shows an unsuccessful attempt to rotate a 530-lb. shell on $5\frac{1}{2}$ inches of stud-bearing, instead of employing the $15\frac{1}{2}$ feet of iron-bearing which is available upon the centering rib-system.

Common Shell.	Total length to be rotated.	Weight to be rotated.	Short stud-bearing.			Long rib-bearing.		
			No. of grooves.	Tangent of stud.	Total bearing.	No. of grooves.	Length of body of shell.	Total bearing.
	in.	lbs.		in.	in.		in.	in.
11·6-in. } 35 ton gun ..	29	534	9	·6	5·4	7	20·16	141·12
12-in.	34·45	700	9	·6	5·4	7	22·25	155·75
13-in. .. .. } 25 ton gun	29·3	600	10	·6	6	7	16·3	114·1
12-in., original,..	36·15	600	9	·6	5·4	7	23·85	166·95
12-in., reduced,..	30	495	9	·6	5·4	7	17·8	124·6
11-in., original,..	37·6	530	9	·6	5·4	7	26·525	185·675
11-in., reduced,..	27·5	402	9	·6	5·4	7	16·425	114·975
10-in., reduced, 18 ton gun..	32·5	400	7	·6	4·2	5	22·56	112·8
9-in., $12\frac{1}{2}$ ton gun	$26\frac{3}{4}$	250	6	·6	3·6	5	17·75	88·75
8-in., 9 ton gun	24·17	180	4	·6	2·4	3	16·27	48·81
7-in., $6\frac{1}{2}$ ton gun	20·4	115	3	·6	1·8	3	13·7	41·1
7-in. *double*, $6\frac{1}{2}$ ton gun	27·2	$159\frac{1}{2}$	3	·6	1·8	3	20·5	61·5

The French or "Woolwich" System.—(Plate XII.) The present service rifling is what was originally called the "French;" but ultimately, the grooves having been reduced in depth, the "Woolwich" system. It consists of deep, broad grooves cut with an increasing twist, each of which receives two soft-metal circular studs attached to the projectile. The original form of button and groove was presented to the French Government by Colonel Treuille de Beaulieu, in 1842, and, in a modified form, it was adopted in our service in 1865, after the 7-inch gun competition. That competition had not proved the superiority of the French to other systems, but sufficient worth was discovered in it to afford some hope that, under Major Palliser's able and ingenious manipulation of the studs, it might suffice for general purposes. Seven years energetic and intelligent labour have been bestowed upon the system by the manufacturing departments at Woolwich, whose chiefs are second to none in capacity and zeal. Seven years have all the resources, intellectual and material, of a government establishment been freely devoted to improving the "French" stud system; and we may now confidently affirm that if it has failed in any particular, this cause of failure must be looked for, not in the manipulation of details, but in the principles involved.

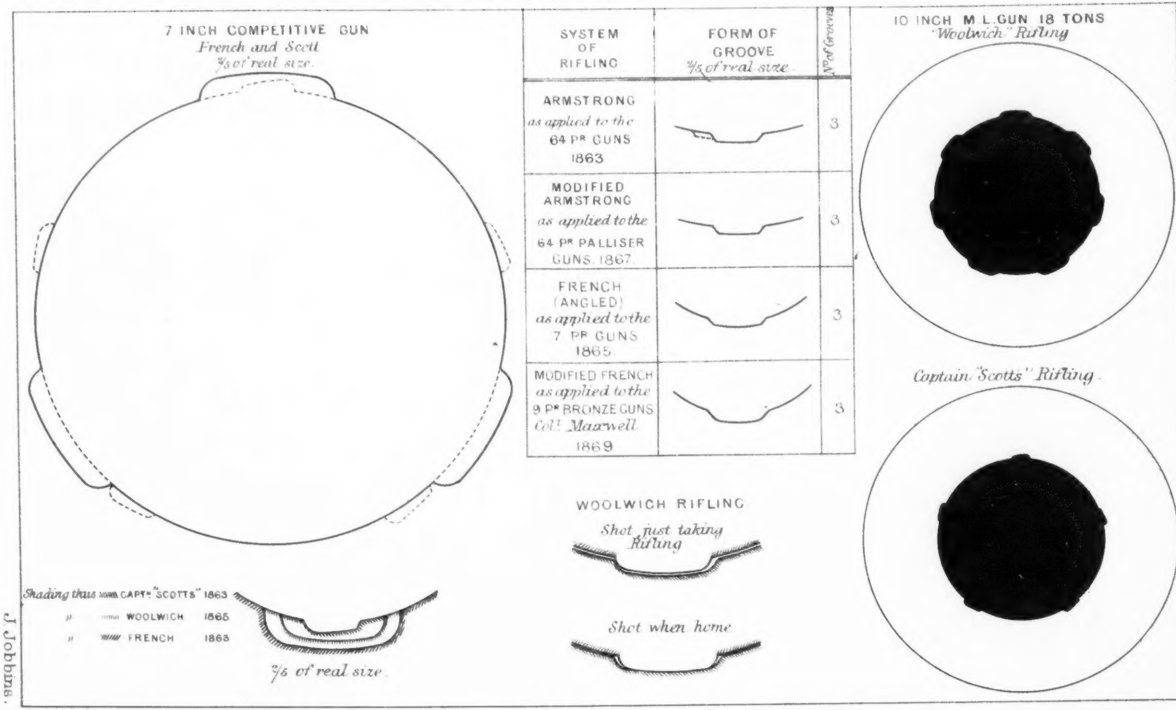
The reasons assigned by the Ordnance Select Committee in 1865, for preferring the French or "Woolwich" system are thus stated in their Report: "*The shooting qualities of these guns are so nearly alike*, that "the Committee feel they may rest their recommendation of the one or "the other system upon other and more general considerations, and "they have finally determined to record their unanimous opinion in "favour of the so-called French system, 1st, because of the simplicity

"of its studding on the projectiles; 2nd, the simplicity of the grooving "of the gun; and 3rd, from a disposition to admit of the advantage "of an increasing over a uniform spiral, which has been strengthened "by the present trial. This advantage can best be realized with *a* "*short bearing* on two points."

The Increasing Spiral. (Plate XIII.)—The increasing spiral has, notwithstanding this Report, been abandoned for this nature of gun, the 7-inch, and has not been used with any lighter guns, and only obtains in its entirety in four natures of guns, the increase being from nothing, *i.e.*, from a straight groove at the seat of the shot to one turn in 40 calibres at the muzzle in the 8-inch 9-ton gun; to one turn in 45 calibres at the muzzle in the 9-inch $12\frac{1}{2}$-ton gun; to one turn in 35 calibres at the muzzle in the 11-inch 25-ton gun, and in the 12-inch 35-ton gun. But a compromise of twists obtains in the 10-inch 18-ton gun, the spiral of which begins at one turn in 100 calibres at the seat of the shot, and increases to one turn in 40 calibres at the muzzle; and in the 12-inch 25-ton gun, to one turn in 50 calibres at the muzzle. The latest idea evidently is to begin with a straight groove, and gradually to reach a spiral of one turn in 35 calibres at the muzzle, though I have been unable to find a single experimental fact to justify it, and it has produced the worst results.

The angle of spiral required to impart adequate rotation to projectiles of different lengths has been experimentally determined by Sir Joseph Whitworth, for guns with long iron bearings. But the number of calibres in which one turn of rifling is to be effected on the present service system, is limited by the incapability of six-tenths of an inch of bearing to sustain the effort of rotation, if the effort be increased by the use of more rapid angles. The practical formula adopted is, therefore, that popularly known as the "rule of thumb." By applying this formula to the varying degrees of spiral which exist in the "French," or "Woolwich" grooved guns, it will be found to coincide with each and all.

The professed object of the increasing spiral is to enable the shot to slip away easily from its seat, and give room for the powder gases to expand, and then to grip the projections of the shot whilst in full flight when it is near the muzzle and give it the necessary spin after the powder-chamber has been relieved of its initial pressure. On the other hand, a uniform spiral grips the shot in a state of rest, and impresses on its first and slowest motions the rotation with which it is intended that it should leave the gun. The question is, which brings least strain on the gun, the effort to grip the shot after it has attained great velocity, and to turn it out of its headlong flight with a view to giving it the requisite spin, or the effort of impressing this rotation upon it at once as it begins to move? The War Department answer by applying the uniform twist to all the guns of and under 7 tons weight, including the longitudinally weak converted or half cast-iron guns; and the increasing twist only to the strong wrought-iron coil guns which are supposed to be capable of standing anything. The American General Gillmore attributes the blowing off of their muzzles by the 23 hybrid Parrott guns at the siege of Charleston to the increasing twist.


7 INCH COMPETITIVE GUN
French and Scott
2/5 of real size.
SYSTEM OF RIFLING
FORM OF GROOVE 2/5 of real size.
No. of Grooves
ARMSTRONG as applied to the 64 Pr GUNS 1863
3
MODIFIED ARMSTRONG as applied to the 64 Pr PALLISER GUNS. 1867
3
FRENCH (ANGLED) as applied to the 7 Pr GUNS 1865.
3
MODIFIED FRENCH as applied to the 9 Pr BRONZE GUNS Col. Maxwell. 1869
3
10 INCH M.L. GUN 18 TONS
"Woolwich" Rifling
Captain "Scotts" Rifling.
WOOLWICH RIFLING
Shot just taking Rifling
Shot when home
Shading thus CAPTn "SCOTTS" 1863
" WOOLWICH 1865
" FRENCH 1863
2/5 of real size.

J. Jobbins.

The early Lancaster guns lost their muzzles from the same cause; and none have so failed since the increasing spiral was abandoned. Colonel Owen's "*Modern Artillery*" tells us that an experiment with increasing and uniform twists showed considerable difference in initial velocity. Five rounds were fired with each twist from the 8-inch gun, the shot (hollow) weighing 179 lbs., and the charge being 30 lbs. The mean initial velocity, and the corresponding blow at the muzzle, given by—

	Velocity.		Total energy.
The uniform twist was	1,338·6 feet	=	2,237 foot tons
The increasing twist	1,303·3 feet	=	2,121 foot tons
Penetrating power lost by increasing twist	35·3 feet	=	116 foot tons

The Admiralty of 1865 were dissatisfied with the absence of all foundation for the favour shown to the increasing spiral, and "at the request "of his Grace the Duke of Somerset, who desired to test the relative "qualities of increasing and uniform twists," two 7-inch $6\frac{1}{2}$-ton guns were prepared and tried with "Woolwich" rifling, but with the two kinds of twist, each ending in one turn in 37 calibres. The initial velocities and the corresponding blows for shot of $115\frac{1}{2}$ lbs., with 22 lbs. R.L.G. charge, were:—

	Velocities.		Total energy.
Uniform twist............	1,465·0 feet	=	1,712 foot-tons.
Increasing twist..........	1,443·8 feet	=	1,656 „ „
Penetrating power lost by increasing twist.......	21.2 feet	=	56 foot-tons.

"The blow struck by the one shot on leaving the muzzle, would be "to that struck by the other, as 100 to 103." Using 12- and 14-lb. charges, "with hollow shot the uniform spiral continues to yield a "slight superiority in accuracy over that of the increasing spiral." The Committee, however, had some speculative theories about the greater initial velocity being due to increased pressure in the powder chamber, and uphold their former guess in favour of the increasing spiral. But Colonel Younghusband, R.A., no mean authority, "records his dissent from the opinion of the majority of the Com-"mittee, and does not consider the adoption of an increasing spiral as "warranted by the present comparison." The Admiralty agree with that officer, though they have all these official reports and tables of practice before them, and order that their then great broadside gun, the 7-inch, shall have an uniform twist. More recently the Committee on Explosives have shown that, with R.L.G. powder, the maximum pressure in the chamber is relieved by the first *quarter of an inch* of onward movement, but there is not, and cannot be, a tittle of evidence to show that any difference of velocities obtains between the two forms of spiral in that quarter of an inch. In the case of pebble powder, the maximum pressure of which is about one-half that of R.L.G., this does not occur till the shot has moved six inches, by which time the uniform spin is fully impressed. Further, the Committee on Explosives report, 1st

January, 1871, on some experiments with a 10-inch gun in its smooth-bore and in its rifled state that, "The general results exhibit a slight diminution of velocity, and likewise a slight *diminution of pressure* consequent on rifling. These results are insufficient to form a basis for any general conclusion; they, however, appear to indicate that there is *no important difference in either velocity or pressure between the gun in its rifled and in its smooth-bore state.*"

If this be anything like the truth, then the guess made, in 1865, as to a uniform twist giving more pressure in the chamber than the increasing, is a proved absurdity, for neither give more powder pressure than a plain unrifled cylinder. The extra initial velocity of the uniform twist does then arise from the greater ease with which the shot escapes out of the muzzle. And the difference of endurance is to be looked for not in the powder chamber, but outside the area of maximum powder pressure, in the grooves and lands of the bore, and in the marks and strain on the projectile.

We have further evidence that difference of powder pressure within the possible limits due to the adoption of an increasing or of an uniform spiral, has little or no effect on the longevity of guns. Take two extreme cases, 1st, that of the 7-ton gun, bored up to 8 inches, and now in use to test powder pressures, &c. It has 21 holes, each an inch in diameter, made right through its walls, at different points from breach to muzzle. In this enfeebled state it has fired many hundred rounds of 35-lbs. charges with 180-lb. shot, though the gun was only built for 22-lbs. charges and 115-lb. shot in its perfect state. 2nd. That of the 10-inch 18-ton gun, now in use for a similar purpose, which has 18 similar holes, communicating from the exterior into the bore for the insertion of crusher gauges. In this weakened state it has fired many hundred powder charges, each of from 60 to 87½ lbs., with 400-lbs. shot, the strains resulting from some of the R.L.G. charges being over 60 tons on the square inch. Yet this gun is as strong as ever. Hence it is evident that pressure in the powder chamber, within ordinary limits, is not the usual cause of the maladies to which the present service guns are heir.

Effort of Rotation.—The greater relative strain on the gun caused by the French rifling over that caused by the Scott rifling, was remarked in 1863 in the report of the rifled cast-iron gun competition. Taking as a comparative measure, the average pressure, as far as the trunnions, multiplied into the resistance or weight moved per square inch of section, the relative strains were in the ratio of 923 tons to 720 tons, and accordingly the French cast-iron rifle-gun burst at the 107th round, whilst the Scott did not do so till the 310th*. This evidence is not, perhaps, so conclusive as to the spiral as the 8-inch gun experiment

* This was the second gun thus rifled. The first cast-iron 32-pr. gun rifled for long iron bearings for this competition, was cheaply and imperfectly grooved at the inventor's own cost; and, as can be seen in this Institution, the experimental shot were ill-shaped at the base for endurance, and the iron ribs of a bad form, quite different from those subsequently adopted. These imperfect projectiles were 41 lbs. weight, and were fired with excessive powder charges of 7 and 7½ lbs., which burst the gun at the 79th round.—W.D.

referred to by Colonel Owen, for the short-bearing stud may account for much that was bad in the French or Woolwich gun, as compared with the long-bearing rib; but that the increasing spiral had something to do with it may be inferred from the fact that the relative strain on the studded Shunt cast-iron gun with a uniform twist is recorded as 798 tons, though it did not burst till the 327th round.

As to strains incidental to the form of groove, independent of the nature of the twist, Mr. J. Anderson, the talented Superintendent of Machinery at the Royal Arsenal, some years ago tested experimentally the strain to the gun resulting from the effort to rotate projectiles by different systems of uniform rifling. Several cast-iron cylinders, of equal strength and area were bored and rifled on each of the various plans. Into these rifled cylinders corresponding plugs of steel representing the projectile were correctly fitted; the other end of the steel plugs being fixed into immoveable frames. The cylinder was fixed in the centre of a lever fulcrum, capable of having a torsional motion given to it by the application of weights on the extremity of the lever. The greater the weight required to fracture the cylinder, the more the endurance due to the given system of rifling; and by dividing the breaking weight by the number of grooves or bearings, we get the endurance of each bearing. The result, given at p. 583 of the Report of the Select Committee on Ordnance, 1863, shows that the Lancaster oval plug split the cylinder representing the gun when each of the two bearings sustained 3·51 tons; the Whitworth split when each of the six bearings sustained 4·68 tons; Armstrong's "Shunt" stud (which is the nearest approach to the "Woolwich" stud tried) split when each of its three grooves sustained 8·55 tons; whilst Scott's did not split until each of the three grooves sustained 11·77 tons.

	Breaking weight at circumference.	Breaking strain each bearing.
	Tons.	Tons.
Lancaster's oval	7·02	3·51
Whitworth's hexagon	28·07	4·68
Armstrong's three groove shunt	25·65	8·55
Scott's three grooves	35·30	11·77

The Heavy Gun Competition.—As there has been only one heavy gun competition (the 7-inch, of 1865) in this country, I am compelled to refer to the facts then obtained in judging of the comparative value of the only systems for such weapons of which we have official comparative experience.

The Report on the 7-inch gun competition tells us that "the gun "rifled on the French (Woolwich) system has* decidedly the lowest

* See "Extracts from Reports, &c., of Ordnance Select Committee," vol. ii, p. 292, sec. 13. In the version of the Report presented six months afterwards to Parliament, this statement is qualified by interpolating at page 4 the unmeaning expression "*somewhat* decidedly the lowest velocities," which hardly does justice to 133 foot tons lighter muzzle blow than the centering ribbed-shot.

" velocities." When firing a 110-lb. shot, " in order that the very " best shooting qualities of the guns might be developed," Scott's gun with uniform twist, gave with a 25-lb. charge, 59 feet greater initial velocity than the French gun with increasing twist and studs; with a 20-lb. charge, Scott's uniform twist gave 52 feet more initial velocity, and with 12-lb. charge it gave 18 feet more, striking blows 133, 121, and 27 foot-tons heavier with the same weight of shot; or 264 foot-tons more than the battering charge of the present service 7-inch guns. These figures represent the extra difficulty experienced by the slower shot in escaping from the gun, and, therefore, the extra strain thrown on the gun in unnecessarily retarding the shot, and gripping it when at full flight instead of when at rest. Accordingly we find this extra strain telling on the gun and recorded in the same report. After the " French " gun had fired 567 rounds, and the Scott gun 417 rounds, they were both examined by the Inspector of Ordnance, who reports certain minor damages common to both, and a more serious cavity in the axis at the bottom of the bore, due to the conical form of their chambers, and then enumerates the following extra punishment inflicted upon the " French " gun by its own studded shot and increasing twist:—" The " A tube is cracked longitudinally in the leading corner of the up- " groove, from $11\frac{1}{2}$ to $19\frac{1}{2}$ inches from the bottom of the bore.

" The dents in lands and grooves, from $20\frac{1}{2}$ to $21\frac{1}{2}$ inches from " bottom of bore, appear to have slightly increased in depth;" whilst Admiral Dunlop inspected the Scott gun, in which the grooves were as accurate as when they left the machine, the original gauge completely filling the bore.

" The bore " of the " French " gun was " also slightly enlarged;" the maximum enlargement being ·049 inch at 21 inches from the bottom, whilst the Scott gun's was only ·002 inch.

" This gun," proceeds the Report, " should, in future, be fired '*under precaution*,' " *i.e.*, in anticipation of a burst.

The last heard officially of these two competitive guns is in a Parliamentary return, April, 1866, when, besides the defect in the axis of the piece due to the conical form of chamber, it is remarked that the " French " gun is " cracked in the tube," and that the Scott gun is " since bored up to 8·03 inch." The same return tells us of another 7-inch gun of 5 tons, of which " the inner tube was split, and the " gun received a new one " at the 800th round; and the practice being continued with the new tube, at the 50th round " there is a slight " indication of a crack in the corner of one of the grooves on the " driving side, nearly at the end, and a wearing of the edge of the " grooves commencing $7\frac{1}{2}$ inches from the end." Was this the reason why the increasing twist was abandoned for all guns of 7 inches and under?

Turning from the effect of an increasing twist, a deep wide groove, and short bearing upon the gun, to that upon the range, we find, by the only " heavy " gun competition, (with 7-inch calibres in 1865), that it takes 25 lbs. of powder to send the same weight of shot the same distance as it is sent when provided with the long iron-bearing flanges and uniform twist when fired with a 20-lb. charge at the

elevation due to what the late Director-General of Naval Ordnance esteems the practical fighting distance at sea, viz., 1,473 yards. This saving of one-fifth of the powder charge must have a most beneficial effect on the erosion of the bore, and consequently on the life of the gun. As the same range is attained by the centering ribbed shot with a less initial velocity, it is evident that the French shot lost range by eccentric and noisy gyrations in the air, due to its wabbling and hammering motion in the gun.

Solid 110-lb. projectile.	Powder charge.	Initial velocity.	Total energy at muzzle.	No. of rounds.	Elevation.	Mean of all ranges.	Mean diff. of range.	Mean reduced deflection.
	lbs.	feet.	foot-tons.		°	yards.	yards.	yards.
Scott's iron-ribbed	25	1,583	1,908	15	2	1,585	17·7	1·1
French zinc stud	,,	1,526	1,775	,,	,,	1,473	62·2	1·9
Scott's iron-ribbed	20	1,493	1,701	15	2	1,473	18·1	1·3
French zinc stud	,,	1,441	1,580	13	,,	1,379	37·1	0·9
Scott's iron-ribbed	12	1,270	1,222	5	2	1,213	21·4	0·8
French zinc stud	,,	1,252	1,195	4	,,	1,152	19·7	0·8

Higher elevations are, for naval purposes, of little consequence, but it is interesting to note that the 110-lb. centering iron-ribbed shot gave at 5°, with 25-lb. charge, as a mean of fifteen rounds, 2,914 yards range, being 163 yards more than the short-bearing studs, and with slightly better accuracy, though an arithmetical error in the report makes it the reverse; and at 10°, which is of still less consequence, the iron-ribbed shot gave, with 25-lb. charge, as a mean of fifteen rounds, 4,798 yards, or 259 yards more than the short-bearing studs, the accuracy being again in favour of the long-bearing ribs. With 20-lb. and 12-lb. charge a similar superiority of range and accuracy was recorded for the long-bearing 110-lb. shot, save that with the latter charge a greater mean lateral deviation from the mean line of fire at 3,909 yards, proved that the angle of twist then adopted by Scott (one turn in forty-two calibres) was less effective in securing rotation than that selected for the French gun—one turn in 37 calibres.

Subsequently "the arrangement of the studs was altogether altered, "on a plan suggested by Major Palliser, the metal was changed from "zinc to gun metal, the smaller stud was placed in front and the larger "behind; both were attached in a different manner," and the weight of both shot was reduced to 100 lbs.; Captain Scott being unhappily induced to try the effect of a soft zinc lining for the iron flanges. The result was that the shooting of the centering-iron shot was spoilt by the soft bearing, whilst the shooting of the French gun was improved by the hard bearing. Still we find that, correcting the arithmetical errors of "Table II. Practice for Range and Accuracy," and taking the mean of the ranges given with 12-lb., 20-lb., and 25-lb.

charges at Admiral Key's fighting ranges, the spoilt centering-ribbed shot obtained 53 yards more range at 1,377 yards, and 30 yards more at 2,543 yards than the French improved by Palliser's stud. The initial velocities and consequent blows at the muzzle were also greater with the spoilt centering rib, using 25- or 12-lb. charges, though, strange to say, it was somewhat less with a 20-lb. charge than the French, but sent its shot, even then, 97 yards farther at 5°, and 32 yards farther at 2° elevation.

Solid 100-lb. projectile.	No. of rounds.	Elevation.	Mean range.	Mean deviation of range.	Mean reduced deflection.
			yards.	yards.	yards.
Scott's zinc ribbed	31	2°	1,377	45·8	2·1
French, with gun-metal studs	"	"	1,324	20·2	2·8
Scott's zinc ribbed	30	5	2,543	50·8	3·2
French, with gun-metal studs	25	"	2,513	35·1	2·3

The ranges at 10°, being beyond useful fighting distance, are of no practical value; but it is interesting to note that the spoilt soft zinc-ribbed 100-lb shot gave, taking the means with all three charges, 4,133 yards, or 249 yards less than similar mean ranges with all three charges, using the iron bearing 110-lb. shot, and 142 yards less than the Palliser hard studded French 100-lb. shot.

As round shot have special advantages in ricochet for sea service, this point was tried with 12-lb. and 20-lb. charges, the means of 65 rounds, giving a range of 86 yards in favour of the shallower and narrower grooving for the centering rib:—

$43\frac{1}{2}$-lb. round shot.	Mean range.	Mean difference of range.	Mean reduced deflection.
	yards.	yards.	yards.
Scott's gun	1,818	81·6	11·5
French gun	1,732	55·9	6·7

The initial velocities taken with round shot, and the corresponding blows at the muzzle, show a loss of 117 foot-tons in the blow given by the French gun. They were:—

$43\frac{1}{2}$-lb. round shot.	20-lb. charge.		12-lb. charge.	
	Initial velocity.	Total energy.	Initial velocity.	Total energy.
	feet.	foot-tons.	feet.	foot-tons.
Scott's gun	2,162	1,410	1,827	1,008
French gun	2,081	1,307	1,718	891
Lost by wide deep grooves....	81	103	109	117

The report of the cast-iron gun competition, with rifled 32-pounders in 1860–3, shows that at 2° elevation, the French or "Woolwich" rifling gave 270 yards less range than Scott's gun, and at 5° elevation, 267 yards less range. The French cast-iron gun was also less accurate with both elevations, though the increasing spiral ended with an angle of 2° 53′ at the muzzle, Scott's uniform spiral being in the corresponding cast-iron gun only 2° throughout; but the approximate area of bearing surface is given in the Report, as 19·5 square inches with the Scott shot as against only 4·7 square inches in the French one, and the area of the guiding edges is stated to be 3·9 square inches in the Scott, as against ·6 in the French. Doubtless it was the uniform spiral and additional bearing which made amends for the smaller angle of twist, rotating Scott's shot more perfectly, and giving it superior accuracy and range in the cast iron, as in the heavy gun competition.

Rifled cast-iron 32-prs., 1860–3.	No. of rounds.	Elevation.	Mean range.	Mean difference of range.	Mean reduced Deflection.	Rectangle containing half the shots.		Relative weight of bursting charge of shell.
						Length.	Width.	
		°	yards.	yards.	yards.	yards.	yards.	
Scott's	9	2	1,129	19·7	2·4	58·5	7·1	·124
French	30	„	859	20·4	1·78	60·3	4·5	·090
Scott's	30	5	1,975	37·5	2·8	108·7	8·2	·124
French	11	„	1,708	41·8	3·51	125·1	9·6	·090

Returning to the heavy gun competition we find that the mean of the only 60 rounds of common shell, with hemispherical heads, weighing, when filled and plugged, 100 lbs., fired with 20-lb. charges, at $2\frac{1}{2}$°, $5\frac{1}{8}$°, $10\frac{1}{2}$°, after correcting arithmetical errors in the Report, gave the iron rib 36 yards preference.

100-lb. shell and 20-lb. charges.	No. of rounds.	Corrected elevation.		Mean range.	Mean difference of range.	Mean observed deflection.	Mean reduced deflection.
		°	′	yards.	yards.	yards.	yards.
Scott's iron-ribbed...............	1	2	14	1,414	—	1·2	—
" "	19	2	15	1,380	14·1	3.8	1·0
" "	20	5	8	2,557	36·4	17·1	1·8
" "	20	10	5	4,149	35·5	79·7	6·7
Mean of all ranges	..	..		2,375	28·7	25·4	3·2
French, gun-metal studs..........	1	2	14	1,412	—	7·7	—
" " "	19	2	15	1,335	21·3	4·0	0·8
" " "	20	5	8	2,490	33·8	19·0	1·4
" " "	20	10	5	4,119	41·7	93·9	6·1
Mean of all ranges...............	..	..		2,339	32·3	31·1	2·8

Endurance of Guns.—The advantage in range, with all these various projectiles, and the additional force of blow at the muzzle, is chiefly noteworthy because the conditions being alike in all respects, except the length of bearing and twist, it shews, from another point of view, that the slower shot which attained the smaller range had greater difficulty in escaping from the bore, and that the extra effort of rotation with the increasing twist and short-bearing threw so much more strain upon the gun.

This extra strain is evidenced by the projectiles occasionally dragging their studs across the lands, or breaking up in the bore, and wearing out the steel linings of the guns, by abrasions and cracks in the grooves, or by the erosion of the escaping gases; so that the 10-inch 18-ton gun is officially regarded as only capable of firing 500 rounds, of which half to be battering charges, and the 11-in 25-ton gun, 250 rounds, of which 100 may be battering charges, before careful professional examination. No rule has yet been laid down as to the limit of the discharges of the 35-ton gun; but as the lining cracked at the 68th round, its endurance is probably much less than that of the 25-ton gun. What would be the life of these heavier guns, if subjected to rapid firing in a naval engagement, has not been tried.

Endurance of Studded Projectiles. (Plate XII.)—Though the programme of the 7-inch gun competition stated that its object was to ascertain "which of these five systems of projectiles and four systems "of rifling is to be preferred," little attention was bestowed upon the question of endurance as affecting the hollow projectile. But eighteen months afterwards, on the 13th December, 1866, Colonel J. H. Francklyn, Commanding Royal Artillery, Halifax, Nova Scotia, reports:—"In the "last lot of 9-inch shot (by the barque 'W. G. Putman') there are a

"considerable number that appear to me quite unfit for issue in their "present state, as some of the *studs are shapeless blotches of gun-metal,* "scarcely projecting at all from the surface of the shot, and evidently "quite unfit to get a grip on the grooves of the gun, if fired; this "appears to be either that the studs have been bruised down, and "worn away by the shot grinding together, probably on board ship, or "else that the shot have, by some oversight, been issued in an un-"finished state;" on this, it was "recommended that steel shell should "be issued for transport in boxes, or in coarse gunny bags;" . . . and that there be "an early shipment to Halifax of 200 9-inch Palliser "shell, 100 in gunny bags, 100 with two grummet rings snaked "together, the rings to be outside the studs." By these means, and the occasional use of a file before loading, this difficulty appears to have been overcome. Contrast this with the official report that the iron rib "projec-"tiles have the merit of being of convenient exterior form, easy to pile, "but little liable to injury, and simple in manufacture." The liability to self-destruction on firing is shown by a general order now in operation, that studded "Palliser projectiles which have been fired and recovered, "are not to be used again, as it has been found that they are liable to "break up in the bore when fired a second time," and injure the gun. On the other hand, in the report of the rifle cast-iron gun competition, the Superintendent at Shoeburyness remarks in the practice return, 5th March, 1861, of the centering ribbed projectiles, "the old shells have "been fired, on an average, *about six times each;* none have cracked;" showing that casting long flanges on the projectile imparts strength, and that diffusing the effort of rotation along its whole cylindrical body, saves the life of the shell. And in the 7-inch gun competition, 1865, of 40 studded shell recovered, 28, or 70 per cent., had some of the rear studs displaced or, in two cases, wrenched out, and none were re-fired. In other cases, "it was noticed at each round, from the third to the "sixth inclusive, that a stud appeared to detach itself from the French "shot during flight;" and "in rounds 306 to 309 inclusive, it appeared "as though a stud fell off during flight."

Five of Scott's recovered 7-inch shell were loaded with powder and re-fired without bursting, confirming the previous experience in 1861, when they were re-fired six times over.

In studding a projectile, a ring of circular holes, each ·3 inch deep and 1·6 inch diameter is cast in the walls from 2·3 inches to 4 inches behind the centre of gravity for the rear studs, the heads of which are 1·45 inches in diameter, and ·195 inch above the surface. Another ring of circular holes of the same depth, but each one-tenth of an inch smaller in diameter, is cast in the walls the same distance before the centre of gravity, for the front studs, the heads of which are 1·2 inches in diameter and project ·195 inch above the surface. The number of holes in each ring correspond to the number of grooves in the gun. Thus, a 9-inch common shell has two rings of six holes each, in its weakest part, reducing its walls, which are $1\frac{1}{2}$ inch thick to 1·2 of an inch over a sectional surface of 9·6 inches in case of the rear ring, and 8·1 inches in the case of the front ring, or for about one-third the circumference. The material of the studs has been the subject of much experiment;

and they now consist of an alloy of 7 copper and 1 tin, except for shrapnel and for 7-inch shells, when the proportions are 10 of copper to 1 of tin. They are swedged cold into the holes in the projectile, which are undercut to receive them, an operation which must further weaken the walls.

Major Palliser explains in his "*Treatise on Compound Ordnance*," that the rear ring of studs being made larger than the front ones, the rear ones at starting do all the work of turning in the slot. As the shot, however, travels up the bore, he says the friction will wear down the rear studs, and the assistance of those in front will thereby be gradually called in. This assistance is, however, so small that it was recently desired to strengthen the shell by doing away with the front ring, which are called mere "guiding" studs, the rear ring being called the "driving" ones. The wearing away of the "driving" studs pointed out by Major Palliser obviously defeats the intention of centering the projectile, or causing its axis to coincide with that of the bore, which he so highly values. The official work on "Ammunition," Part II, page 58, states that the intention of centering the projectile is not realised with studs in consequence of the softness of the gun-metal; and that "the Committee on Field Ord-" nance for India report that recovered projectiles fired from an "experimental 'Woolwich' gun showed clear evidence of non-" centering." The groove for the Indian field guns was made, therefore, with its loading side sloped, and has an uniform twist; and, page 93, "it was found by the Committee that better results were "obtained with this system, which was advocated by Colonel Maxwell, "than with the 'Woolwich,' the projectiles, having a rather greater "initial velocity, and giving better shooting." Nevertheless, the ill effects of the short bearing remained, preventing the use of the original long double 7-pounder shell, and necessitating (page 96) its reduction in length, in bursting charge, and in power. Colonel Owen writes:— "In hard projectiles having studs there will generally be a slightly "oblique movement of the axis of the projectile;" in other words "wabbling" occurs in the bore, the studs are sheared or wrenched out of their sockets; a puffing "noise" is heard in the flight, and if the shell do not break up, they reach their destination broadside on.

That the weakening of the walls by so many holes, and the concentration of the effort of rotation on the rear holes does seriously affect the endurance of the projectile we have much official evidence. The official volume on "Ammunition," Part II, published 1870, after upwards of five years' experience of the "Woolwich" rifling, says, at page 73, "The "effect produced by the pressure on the sides of a M. L. common shell "from the gas rushing past is found to be most remarkable, the shell "having a tendency to assume a form approaching that of a dumb-bell. " . . . The body about the middle, where it is weakest, is forced "inwards and decreased in diameter to an extent which would hardly "be credited. For example, the diameter of a 9-inch shell has been "reduced from 8·92 inches to 8·55" (or ·37 of an inch) "about the "middle." Again (page 91) of "Ammunition," Part II, "A cracked "(Palliser) projectile may be surprisingly easily divided into two by

"a blow on the stud fixed on the present system. If shot are found "split in store, the crack generally runs through stud holes," and the same effect is observed when they break up in the gun or on striking a hard object.

12-*inch 25-ton Gun, Common Shell.*—Turning to the quarterly *Extracts from the Proceedings of the Department of the Director-General of Ordnance selected by order of the Secretary of State for War*, and passing over the first three years after the adoption of the "Woolwich" system, we find it reported, in February, 1868, of the 12 common shell 600 lbs. weight, 36·15 inch long, containing 45½ lbs. bursting charge, that "the "practice with the common shells was stopped on account of the "shells appearing to turn over in flight. All had two studs in each "groove, eighteen in all; but they were . . . . only six "inches apart." In March, 1868, of ten rounds fired with 55lbs. charge "two surged in flight; eight very unsteady." Of ten rounds fired with 60 lbs. charge, "all very unsteady." "A shell struck the "muzzle in loading and dropped on ground out of the lifter. In ram- "ming home afterwards, shell jammed, probably owing to studs being "burred by the fall." Another "shell jammed three inches off end of "bore, and could not be forced home." Of ten rounds fired, in April, 1868, with 40-lb. charges, "two tolerably steady, three unsteady at "first but steadied; one unsteady, and four very so." "An additional "rear ring of studs of reduced gauge" suggested, but the "committee "prefer to try the effect of reducing the weight of the projectile." Accordingly, the studs being incapable of giving sufficient rotation to the 12-inch common shell, "these proved on trial so exceedingly "unsteady in flight and shot so indifferently" that they were reduced from 600 lbs. weight to 495 lbs. weight, and their bursting charge from 45½ lbs. to 35 lbs. We thus sacrifice 105 lbs. weight in the 12-inch common shell and 10½ lbs. of bursting charge, because a short bearing cannot give rotation to a long shell. Nor is this all. The capacity of the original 600-lbs. 12-inch common shell was determined by the necessity of having walls 1·96 inches thick, to allow for two rings of nine circular holes, each ·3 inch deep and 1·65 inch in diameter, and for the concentration of the whole effort of rotation on the rear weakening ring. Had that shell been strengthened by seven cast-iron ribs instead of weakened by two rings of eighteen holes, the capacity of the 600-lbs. shell might have been increased to receive a 60-lb. bursting charge, instead of our now being obliged to use a 495-lbs. shell with a 35-lbs. bursting charge.

The official work on "Ammunition" says:—"The weights of all the "projectiles of each calibre (except case shot and double shell) approxi- "mate as nearly as possible, . . . with the 12-inch gun, there is "a serious departure from this system in the case of common and Shrap- "nell shell," owing "to the unfortunate introduction of the 12-inch "gun *with such a twist* as rendered it necessary to discard its two "longest projectiles, viz., its common and shrapnel shells, constructed "at first to weigh about 600 lbs., on the score of bad shooting, for two "shorter and much less powerful ones, weighing only about 495 and "496 lbs. respectively."

The practice with the reduced 12-inch shell is reported (15th October, 1868,) to be "remarkable for its goodness," yet we read "ten shells "have been recovered. In several, the rear studs have been slightly "moved forward by the explosion of the charge, and all are scored on "base (for about $\frac{1}{5}$th of the circumference) by the grooving of the gun; "the length of the scoring averages about 3 inches." If the studs had worked truly, the body of the shell could not have touched the bore at all; the scoring of the base shows that the shell wabbled in, and hammered, the gun.

12-*inch* 25-*ton Gun.*—The bad shooting, and the erosion of the bore still continue after taking one-sixth from the weight and nearly one-fourth from the bursting charge of the shell, it being impossible to give even the reduced projectiles adequate rotation. We find that Colonel Campbell, Royal Artillery, the talented Superintendent of the Royal Gun Factories, submitted a memorandum to the Ordnance Council, on the then proposed 35-ton gun competition, 4th May, 1870, in which he says:—

"The 'Woolwich' system of rifling adopted in the service, required "metal studs on the projectiles, which are objectionable from their "liability to shear, and thus prevent the correct centering of the shot, "and their liability to become damaged in transport and on service. "In heavy guns, the liability to shear, necessitates an increased number "of grooves if a quicker twist than now employed, is given. The "system has the great disadvantage of local scoring. . . . . I mean "to say that there are disadvantages in the 'Woolwich' system in "that way, and a better system of rifling might be found."

Colonel Campbell was asked by the Director-General of Naval Ordnance;—"Do you consider that the increase of the twist given to "this (35-ton) gun will entirely obviate *the inaccuracy of flight now* "*observed in the* 12-*inch gun of* 25 *tons* at very short ranges?" and replied, "*No, I should not think it would altogether*, I think it will "improve it very much. I should like to have given a greater twist."

Again, "should you be afraid if you adopted a sharper twist, say 1 "in 25, that the studs would be sheared?" "I should be afraid so, or "I would have adopted it. The stud in the projectile confines us to "giving a less twist than I should like to give to any gun."

To which Sir Joseph Whitworth truly added "if you have projectiles "of a certain length, you must have a greater twist. . . . The "question is, is it desirable to be able to fire a shell six diameters long "holding a double charge of powder? If you say 'yes,' then you "must have a greater twist, because with less, the projectile turns "over."

The "Monarch's" four 25-ton guns having been examined after firing an average of only 35 charges each, 20 being battering charges, were reported, April, 1870, to have "a very slight burring up of the "driving sides of the grooves for a short distance from their origin. "This is just to be perceived in all the guns" (though two of them had only fired 9 battering charges each) "but is so slight as *at* "*present* to be quite unimportant." One of the guns had to be re-vented.

11-*inch* 25-*ton Gun*.—This and the 35-ton guns are the only ones in which, with an increasing spiral, so rapid a final twist as one turn in 35 calibres, obtains. Let us observe the result. It was computed that by reducing the 12-inch 25-ton gun to an 11-inch bore, it gave with the same 70-lbs. R.L.G. charge, but with a 70-lb. lighter shot, *i.e.*, a 530-lb. shot instead of 600 lbs., five foot tons per inch of shot's circumference, more penetrative power both at the muzzle and at 1,000 yards, though of course the total energy or hitting force was greater in the 12-inch. Thus, at 1,000 yards, the 70-lb. R.L.G. was computed to give—

	12-inch. 600-lbs. shot.	11-inch. 530-lbs. shot.
Velocity	1,108 ft.	1,149 ft.
Total energy	5,108 ft. tons.	4,852 ft. tons.
Energy per inch of shot's circumference ..	136·4 ft. tons.	141·4 ft. tons.

Powder-pressure experiments are not always reliable; but it was at one time stated, that the pressure on each square inch of the 11-inch powder chamber, using R.L.G. powder, was $\frac{12}{100}$ths greater than the 12-inch; but that the strength gained by the extra metal rendered the 11-inch gun more than $\frac{22}{100}$ths per square inch stronger than the 12-inch; the balance of endurance, and the penetrative power, lying therefore with the 11-inch bore. But the proper calibre is a question of compromises, and a 12-inch shell, with its extra weight, large hole, and large bursting charge, and the impossibility of giving rotation by studs, and increasing twist to the proper sized shell for either bore, have to be placed on the other side. At present the authorities have decided for the smaller bore.

With pebble powder the penetrating power of the smaller bore is, however, at 1,000 yards, only one foot-ton on each inch of the shot's circumference greater than the 12-inch. But after practice at the two turret targets at Shoeburyness, the Committee report, of the 25-ton guns that, "There is little practical difference in their perforating "powers when firing the same charges; the total work done, however, "by the 12-inch gun is greater than that done by the 11-inch." These turret targets, 14-inches thick, were a match for the 10-, 11-, and 12-inch guns, but afforded little margin of protection. It may be interesting to observe the work done at 1,000 yards when employing pebble powder, and when using R.L.G. in various calibres.

At 1,000 yards:—

12-inch. 25-ton gun. 85 lbs. pebble. 600 lbs. projectile.			11-inch. 25-ton gun. 85 lbs. pebble. 535 lbs. projectile.			10-inch. 18-ton gun. 70 lbs. pebble. 400 lbs. projectile.			9-inch. $12\frac{1}{2}$-ton gun. 50 lbs. pebble. 250 lbs. projectile.			8-inch. 9 tons. 35 lbs. pebble. 180 lbs. projectile.			7-inch. $6\frac{1}{2}$-tons. 30 lbs. pebble. 115 lbs. projectile.		
Velocity.	Total energy.	Energy per inch of shot's circumference.	Velocity.	Total energy.	Energy per inch of shot's circumference.	Velocity.	Total energy.	Energy per inch of shot's circumference.	Velocity.	Total energy.	Energy per inch of shot's circumference.	Velocity.	Total energy.	Energy per inch of shot's circumference.	Velocity.	Total energy.	Energy per inch of shot's circumference.
feet.	foot-tons.	foot-tons.	feet.	foot-tons.	foot-tons.	feet.	foot-tons.	foot-tons.	feet.	foot-tons.	foot-tons.	feet.	foot-tons.	foot-tons.	feet.	foot-tons.	foot-tons.
1,179	5,780	155	1,199	5,335	156	1,228	4,185	134·2	1,236	2,648	94·5	1,213	1,837	73·8	1,261	1,268	58·3
70 lbs. R.L.G.			70 lbs. R.L.G.			60 lbs. R.L.G.			43 lbs. R.L.G.			30 lbs. R.L.G.			22 lbs. R.L.G.		
1,108	5,108	136·4	1,149	4,852	141·4	1,177	3,842	123·3	1,175	2,393	85·4	1,161	1,682	67·6	1,196	1,141	52·5

11-*inch 25 ton Gun, Common Shell.*—"The same difficulty," proceeds the Report, "has been experienced with the common shell for the "11-inch gun," which were 530 lbs. weight, and contained 40-lb. bursters, and were 37·6 inches long. "The practice with common "shell (and 54 lbs. and 65 lbs. Pellet powder charges) was discontinued "on account of their extreme unsteadiness in flight, by order of the "Ordnance Select Committee who were present, 22 September, 1868. "Two rounds were fired with 65-lbs. charge to ascertain what effect the "increased charge had on the shooting; the inaccuracy of the shells "was, however, greater than before." Accordingly, 128 lbs. in weight, 10·1 inches in length, and 15·8 lbs. bursting charge are sacrificed in the common 11-inch shell, because the short bearing studs fail to give rotation to a shell such as the gun, properly rifled, could easily project. Nor is this all, for had not the walls of the original 530-lbs. shell been weakened by two rings of 1·6 inch holes ·3-inch deep, but had been strengthened by rib buttresses, it might have contained 50 lbs. of powder, instead of the 24·2 lbs., to which the 402-lbs. shell is now reduced. The difference of bursting charge, and of weight of projectile, represent part of the payment for an increasing twist, and for concentrating the effort of rotation on a short-stud bearing. Even, after making this enormous sacrifice of useful effect, we find that the practice recorded in July, 1871, showed four shot "unsteady" or "noisy" out of 30 fired; and so recently as August, 1871, we are told, "the common shell which have been supplied, have proved too weak, "and a stronger pattern has been demanded."

11-*inch Palliser Shell.*—The weak point is thus officially noticed, 7 December, 1868:—"the 11-inch Palliser shell supplied, proved too "weak to withstand the battering charge. Two shells broke up in the "gun, and three on graze. Charge 67 lbs. R.L.G. powder. Drawing "of a stronger shell demanded." "The broken shells have been re-"covered, and out of the eight fired, only two are undamaged. The

"condition of the rest are as follows:—One with head broken into three "pieces and off *at front row of studs*, &c. . . . the body of the "shell was broken up through the base into four large pieces; this was "the eighth shell fired and broke up in the gun. One with head broken "off entire *at the front row of studs;* the body was broken up through "the base into several large pieces. This was the seventh shell and "broke up in the gun. Four with the heads broken off *entire at the* "*front row of studs;* two of these broke at first graze, and two at "last graze."

10-*inch* 18-*ton Gun*.—This and the 9-inch $12\frac{1}{2}$-ton gun are likely to be favourite naval guns. One or both will enter into all decent broadside armaments. On Scott's carriages they are handy pieces, and can be easily carried by most strongly-built ships. The 10-inch projectiles would strike a harder blow at 2,000 yards, or perforate as well at 1,500 yards, as the 9-inch at the muzzle.

At 1,500 yards:—

	10-inch, 400-lbs. shot, 60 lbs. R.L.G.	9-inch, 250-lbs. shot, 43 lbs. R.L.G.
Velocity	1,118 ft.	1,108 ft.
Total energy	3,467 ft. tons	2,128 ft. tons.
Work per inch of shot's circumference.. ..	111·2 ft. tons.	75·9 ft. tons.

As the 9-inch gun would perforate the "Lord Warden," or "Bellerophon," at 1,000 yards, and the "Warrior" at 2,000 yards, if not at a greater distance, it is a very suitable weapon as the standard broadside gun; whilst a few 10-inch guns would serve to dispose of 8-inch armour, and its backing at that range. Many of these guns have long been afloat, but the Navy cannot recover fired shell to examine how many studs have been wrenched out or shaved off; nor, with steam blowing off, can the "noise" of "unsteady" projectiles always be heard; nor, are observations often taken at right angles as to accuracy of the range; nor can arrivals at the target broadside-on instead of end-on be readily noted. Yet it is stated by observant Naval Officers that the studded projectiles make an intermittent puffing noise in their flight, like a locomotive steam-engine starting on its travels; and quite unlike the uniform whiz of the lead-coated shot,—every "puffer" being a wabbler and a hammerer of the bore. The breaking up of projectiles is also frequently noted. The Navy does not record, or recording, does not publish to its officers, any of its gunnery experiences. We are, therefore, driven to the War Department for official naval intelligence, scraps of which are given in those "Extracts of Artillery Proceedings," which are circulated for the information and instruction of military men. "Keep your officers ignorant and they will obey you," is now the received naval rendering of Earl St. Vincent's well known saying, "Keep your officers poor, and they will serve you."

The 10-inch gun being grooved with a less increase of twist, approaching, in fact, to the uniform spiral, its shell has not been so heavily taxed as the 11-inch one, still the short bearing remains to sacrifice a good deal of its efficiency.

Passing over the experimental stages, we come to ten common shell fired with 40 lbs. R.L.G., on the 14th Febuary, 1868, "eight unsteady;" then, 19th March, ten fired with same charge, "one noisy; two a "little so." In April "a recovered 10-inch Palliser shell, fired with a "charge of 60lbs. R.L.G. powder, broke up in the gun. The bore is "badly scored, particularly No. 1 groove . . . The recovered shell "showing a tendency to break up . . . . he requests that a suffi-"cient number of" shot be sent. It was found that "No. 1 groove "up is slightly *burred on driving edge* from muzzle to 54 inches, and "slightly scored to 78½ inches. Also deeply cut into from 32½ inches "to 41 inches." Four other grooves are "slightly burred and scored," and "the bore and grooves slightly grazed all round. . . . The "grooves Nos. 5 and 6 are *slightly dented by studs* of shot at 116 inches." On the 28th May, 1868, "one recovered shell broke up in gun," one new shell "burst in the gun" when fired with battering charges. After 385 rounds had been fired, and "two Palliser cored shot had broken up in the bore," the superintendent of experiments "states that the "bore appears a good deal injured, and fissures are beginning to "appear round the vent." After 400 rounds it is reported, 9th April, 1869, "The scoring in bore caused by the escape of gas extends from "85½ inches to 133 inches, and from 87½ inches to end of grooves "Nos. 1, 2, 3, 4; the greatest amount being from 103 inches to 120 "inches on upper part of bore and in grooves Nos. 2 and 3. The "lower part of the bore and grooves, Nos. 5, 6, 7, are slightly scored by "gas from 93 inches to 125 inches." (The bore is 145½ inches long.) "It now requires re-venting, and he thinks it should be turned over "and re-vented on present 'underside.' This being done, the gun "became unserviceable at the 534th round 'through the tube being "split in the powder chamber, evidently caused by the erosion of the "bore, consequent upon the rush of gas over the projectile.'" The cost of a new steel lining would be £515 3*s.* 8*d.* The history of this gun is that of all, and shows that erosion of the bore, above the shot and consequent hammering down upon the seat, naturally tends either to spike the gun on its own stud, or so to flatten the stud as to admit of the body of the shell touching the bore, in which case the body has to be dragged across the lands rough with fouling matter by the already overworked stud. This erosion above and hammering below are assisted by the great spaces above the shell and between the studs in the deep wide grooves; and would be partially counteracted by a system which nearly filled up narrower grooves along the whole cylindrical length of the shell.

10-inch Palliser Shell.—The grooves of some guns having been injured by the breaking up of projectiles in the guns, telegrams to the Mediterranean and Channel squadrons, in January and February, 1870, forbade the use of Palliser shot, even at targets, lest all should be disabled. Thirty-four 10-inch Palliser shell "fitted with strengthened "base-plugs to prevent premature breaking up," had been fired with 43 and 60 lbs. R.L.G. charges, during the last six months of 1869, from the "Hercules," four of which had broken up in the guns, one being filled with sand, and the other three

with powder; and one of the latter had permanently disabled a 10-inch gun. As the projectiles could not be recovered, the exact cause of failure is unknown, but as the injury occurred, as usual, in the grooves, there can be little doubt that the shell broke up as usual through their stud-holes. The disabled gun, however, had to be returned to the arsenal, for the tube to be patched, the ship, meanwhile, being partially disarmed. Lord Gilford's report states that on the 14th December, 1869, whilst the "Hercules" was firing Palliser shell with battering charges, at a target in the Atlantic, "the A tube in one gun "was found to be split right through to the B tube at the muzzle; "the crack extends from the muzzle to the loading edge of the groove, "10 inches up the bore, where it disappears suddenly. The B tube has "been apparently much strained, immediately above the crack in the A "tube. . . . . This gun as well as" another "lost the lower part "of the vent the same day while firing at a target. When the A tube "was split and the vent damaged, it had fired two rounds on that day "and 43 rounds in all. Also, when the vent of the other gun was "damaged, it had fired 4 rounds, or 46 in all. Only two shells broke "on the 14th December, one of which broke in" each gun. "Three "guns remain serviceable." The Director-General of Naval Ordnance remarks that "the crack in the A tube and the strained condition of "the B tube over the crack are *exactly what I should have expected.*" The Special Committee remark, 31st March, 1870: "It also appears "that a considerable proportion of *steel* shells burst prematurely in "guns when these projectiles were under trial; and, further, that "similar accidents have *frequently* happened to common shell fired with "smaller charges." Thus it would appear that this malady is of frequent occurrence and not peculiar to Palliser shell, but even extends to studded steel shell. In August, 1870, a 10-inch Palliser shell of another "latest pattern," head cast in chill and body in sand, burst prematurely in the "Hercules," on which Colonel Milward, R.A., the distinguished Superintendent, Royal Laboratory, observes, "occasionally "a shell may be expected to burst prematurely, as has always been the "case, but he thinks the evil is now reduced to a minimum." However, the outcome is that the walls were thickened and the bursting charge reduced from 10 lbs. to 6 lbs. 14 oz.

10-*inch Common Shell*.—Additional strength was secured by dispensing with the front ring of weakening studs, and some success, in firing such projectiles in this and other calibres. But the weak point still remained in the "driving" studs, and in May, 1870, out of five projectiles so fitted and fired, one broke in two at the ring of studs; and, of four recovered, one had one of the studs torn off, and the others had their studs worn from ·2 to ·3 inch. The single ring of studs was subsequently abandoned. Experiments were made at Shoeburyness in January and February, 1871, "with ten common shells strengthened "at the rear end . . . . Six of the shells have been recovered, and are "more or less 'set up.' Superintendent, Royal Laboratory, states, "although the result of the practice therein recorded is an improve-"ment on the service pattern shell, still it is not quite satisfactory." In May, 1871, five common 10-inch shell recovered at Shoeburyness

were found "slightly "set up," and scored in some places by the edges "of the grooves, and in others, ground down by the lands of the gun," showing that the studs had been hammered flat by the gas escaping over the shot.

The result is, that the weakened walls of the 400-lb. 10-inch common shell, being unable to sustain this accumulated drag concentrated on one ring of studs, their thickness has been increased from 1·65 to 1·85 inches, the powder capacity being consequently reduced from 32 lbs. to $26\frac{1}{4}$ lbs. The concentration of the effort of rotation on a short bearing has, therefore, caused us the loss of at least $5\frac{3}{4}$-lbs. bursting power; its diffusion over the whole body, the abolition of the increasing twist, and the use of strengthening ribs would probably increase the bursting charge by $13\frac{3}{4}$ lbs.

Even after making this sacrifice, we learn that so recently as July, 1871, an experiment was "carried out, at Shoeburyness, to ascertain "the cause of the premature explosions of Shrapnel and common "shells." Of six common 10-inch shell recovered, there was "one "marked on base by three of the grooves in the gun;" and of fourteen 9-inch common shell, there were "three marked by the grooves of the "the guns, and two marked on 'bases by grooves of gun;'" showing that up to the last published records, the bores of guns are being hammered by their shells as they wabble their devious way out of the guns.

10-inch Shrapnel Shell.—On 4th March, 1871, the breaking up of 10-inch Shrapnel shell having attracted attention, the Assistant Superintendent, Royal Laboratory, states the following were fired at Shoeburyness:—"Charge 60 lbs.; 4 fired, plugged, with bursting "charge inserted; 2 broke or burst in gun, 1 fired fuzed; broke or "burst in gun; 1 fired plugged; broke or burst in gun. Charge 40 lbs.; "3 fired fuzed; 1 broke or burst in gun. He states that it is clear "that the Shrapnel shell, at present made, is quite unfit for service, "and attributes their defects to weakness. He adds that in the mean-"time instructions have been given to suspend the manufacture "and issue of 10-inch Shrapnel shell." Can we wonder that the thinner walls of Shrapnel cannot endure a concentrated effort of rotation which the thicker walls of common shell, as originally constructed, failed to sustain.

9-inch $12\frac{1}{2}$-ton Gun.—Notwithstanding the large experience with this gun, it still suffers occasionally from its own projectiles, whilst the latter are still frequently reported as making an intermittent puffing noise, the result of unsteadiness in their flight, and hammering in the bore.

On the 25th September, 1868, after some years' experience of the best form of construction, and of the French or "Woolwich" system of rifling, a 9-inch gun burst violently at the first round of proof, using $53\frac{3}{4}$ lbs. of powder. There is no evidence whatever, as to the cause of this unusual occurrence. Some persons suppose the steel tube to have been defective, but, even if any evidence of this existed, other guns have enjoyed a long and useful life after their steel tubes have cracked. Thus, in 1865, a similar gun burst easily at the 400th round, with an average charge of 42·81 lbs. and a 217·33-lbs. projectile,

the gun having "held together at least 14 rounds after the tube was "split, during part of which the water was seen to pass through the "gun when it was sponged." Again, another 9-inch gun, which cracked its steel tube at the 707th round, was fired 301 times subsequently before the gas escaped at the rear orifice, and 41 rounds more, or 1,049 rounds in all, before the parts of the structure began to move, and then firing ceased only because the movements of the several tubes had closed the vent. Again, another 9-inch gun, cracked its steel tube at the 203rd round of battering charges, at Tegel, near Berlin, in 1868, but the firing was continued for another 78 rounds with battering charges and 30 with reduced charges, or 108 further rounds without danger. This British-made gun was subsequently re-lined, re-proved, and re-sold for the Prussian Government. Another 9-inch gun, sold to the Austrians, cracked its steel lining at the 111th round when firing prismatic powder in 1870, without any dangerous consequences. In our own country, a 9-inch gun, rifled on the "shunt" system, burst its iron barrel at the 104th round; and being fitted with a steel tube and "Woolwich" rifling, it burst again at the 322nd round, but none of these did so with violence. Whatever faults of construction they may have had, were no doubt strained and forced out by the vicious systems of rifling adopted.

Again, an 8-inch gun used for experimental purposes, has 18 holes bored right through its sides for the admission of removable pressure gauges. It has, in that mutilated state, been fired thousands of times, and subjected to the most extraordinary strains, without showing a symptom of weakness amongst the perforated coils. Indeed, it is boasted of coil-built guns that they invariably give notice of approaching dissolution by undeniable and long continued premonitory symptoms.

It is, therefore, evident, that the violent explosive burst in September, 1868, at the very first discharge, cannot be attributable to an unknown defect in the tube or in the coils, but must have arisen from some other cause. A jam in the bore would account for it all. This jam might easily arise from the breaking up of the projectile across its stud holes; and this breaking up is proved to be one of frequent occurrence. That a broken projectile may be wedged firmly in the bore was clearly shown when the Krupp 8-inch jacketed gun was broken in two on firing at Woolwich, at the point where the broken shot wedged itself, and both gun-muzzle and shot were carried to the proof butts, where they were picked up and examined. The original Lancaster cast-iron guns with an increasing twist which blew their muzzles off, did so by the shot wedging. If it arose from the jamming of a broken up shot, then the increasing twist, short bearing, and ring of weakening stud-holes, have this extraordinary and most dangerous explosive burst at proof to answer for.

The only other explosive burst of a heavy coil gun on record, is that of a 9·22-inch "shunt" gun of the original construction, which burst explosively into 42 pieces at the 402nd round, with an average charge of 39·88 lbs. and 217·33-lbs. projectile. This, again, was obviously not due to the build of the gun, but to the stud-shot and to the squeeze of the muzzle-grip.

If then, the explosive burst be due to the rifling which causes the projectile to break up occasionally in the gun, and not, as seems clear to the steel-tube's defects, such an accident might occur at any moment between the decks of a ship, with similar disastrous results to those which occurred from the bursting of a steel gun on board the Russian frigate "Alexander Nwsgi," in 1868.

In 1869, a 9-inch gun of the "Bellerophon" had to be returned as unserviceable, the studs having wedged themselves over the edge of the grooving. Such an accident in battle would have deprived the "Bellerophon," on one broadside, of about one-sixth of her offensive power. After this ship was paid off eighteen months later, on examination, 28th January, 1871, of ten 9-inch guns, returned from the "Bellerophon," the bore of one gun was found grazed by premature explosion of projectiles; and another considerably scored by the rush of gas over the projectile, although only 22 battering and 143 full charges had been fired from it; a very small number to do so much damage!

Being re-commissioned last autumn, the "Bellerophon" had a 12½-ton gun subsequently disabled by splitting the outer coil near the muzzle, where the increasing twist has the greatest angle, and she had to change the gun at Gibraltar in November last. Venturing to fire two rounds of battering charges at general quarters last month, two other guns attempted suicide, but only succeeded in inflicting remediable injuries upon themselves. Being without official information as to the cause, I can only surmise that the "Bellorophon's" projectiles have the usual ugly trick of breaking up in the gun through their stud-holes opposite the grooves near the muzzle, where the increasing spiral has its most gun-destructive power. But if two rounds of battering charges are so gun-destructive, may we not fairly expect that in a continuous bombardment, the whole fleet would be disarmed?

On the 14th January, 1870, at the 17th round of Palliser shell of the latest pattern, fired with battering charges from the "Staunch," "a "shell either broke up or burst in the gun. Captain Boys thinks the "the former, as no explosion was perceptible." Of 50 Palliser last pattern shell fired in March, 1870, at Shoeburyness, to verify naval complaints of breaking up in the gun, "several" are recorded as "sounded unsteady" and "noisy" in flight.

We learn officially, 30th January, 1870, that "60 9-inch (Palliser) "shell of large capacity have been fired in the 'Staunch' and 'Royal "Sovereign,' and eight in the 'Minotaur.' Of these, one broke up in "the 9-inch gun of the 'Staunch,' disabling the gun, which it was "necessary to send to Woolwich for repair; and a second broke up in "a 9-inch gun of 'Royal Sovereign,' cutting into the bore deeply, "but not disabling the gun." These two accidents are ascribed to the chill given to the body of the Palliser shell, since discontinued; but I submit that this brittle material was rendered more liable to break up, in consequence of two rings of holes in the walls, and of the effort of rotation being concentrated on one of those rings; witness the statement already quoted from the official work on "Ammunition," that "a cracked projectile may be surprisingly easily divided in two, by a "blow on the stud fixed on the present system. If shot are found

"split in store, the crack generally runs through stud holes." In other words, the shot break up opposite the grooves or weakest point in the bore; whereas the strongest portion of the ribbed shell is that which is opposite the groove, and none have ever broken up at the flange, though fired six times over.

The last returns show that in August, 1871, in testing the range at $5\frac{1}{10}°$, of 9-inch Palliser proof shot and Friespong chilled shot, all six fired were "noisy" or "unsteady; and of five recovered, two "Fries-"pong were slightly burred on the driving edges (of studs); in one "(Royal Laboratory) most of rear-row slightly started;" showing that the insufficiency of rotation and shearing of the studs, still continues after all the talent which has been fruitlessly expended on the system.

8-inch 9-ton Gun.—Though this gun is happy in "not possessing a history," or at least an official one, its projectiles are popularly known afloat as "puffers" in their flight, and therefore as wabblers and hammerers in the bore. Artillery progress renders this an unnecessary weapon. The low carriage and high slide with hooked pivots to heavy deck racers, introduced by Captain Scott, enables a $12\frac{1}{2}$-ton gun to be carried where a 9-ton gun was carried before, and it is, therefore, desirable to reduce the variety of calibres by ceasing to manufacture this gun as well as either the 25- or the 35-ton gun.

7-inch $6\frac{1}{2}$-ton Guns.—Notwithstanding the *opinions* expressed in the report of the 7-inch gun competition, the *facts* of that report have led to the abandonment of the increasing spiral in this gun; yet, by a strange hallucination, no advantage is taken of the uniformity of twist to lengthen the bearing, either by the adoption of centering flanges or by increasing the distance between the studs;—those of the double shell being only 4·6 inches apart instead of presenting a rotating surface in each groove of $20\frac{1}{2}$ inches. Thus, notwithstanding the uniformity of spiral, the projectiles are familiarly spoken of as "puffers," and the double shell as "acrobats." By the reduction of the charges from 25, 20, and 12 lbs. of R.L.G. powder to 22, 14, and 10 lbs. respectively; albeit, the projectiles are made 5 lbs. heavier, the blow at the muzzle is now 131 foot-tons less than the original both using battering charges, and no less than 264 foot-tons short of that struck by the similar Scott competitive gun. Whilst the enlargement of the bore observed in the competitive "French" gun, consequent upon the greater escape of gas and the wear of the studs, exists also in its successors. The Committee on Explosive Substances Report, January, 1871:—"In the practice with the 7-inch gun there was found to be a "difference of 30 feet per second between the muzzle-velocities given "by an old gun much scored in the bore, and a new one, when pebble "powder was used, and 70 feet when R.L.G. powder was used;" *i.e.*, a reduction of 180 foot-tons in the blow struck.

When the "Favourite" returned from the West Indies, the grooves of some of her 7-inch guns had, on examination, indications of having been over-ridden by the studs, causing a squeeze which might have been fatal to the projectile, though it did not prove so to the gun.

In December 1869, the 7-inch gun of the "Redwing," tender to the

"Cambridge," was found to have a flaw in its steel tube after firing 881 full charges; and on examination it was reported that "the A tube "is cracked through longitudinally from muzzle to $16\frac{1}{2}$ inches, L of "up. The bore and grooves are slightly scored by gas all round ". . . . The gun can be repaired by the insertion of a new steel "tube, cost £186." The gun was, of course, returned to Woolwich. No doubt the gun was disabled by the breaking up of a projectile in the bore.

7-inch Palliser shot.—On the 25th January, 1870, when the "Warrior" was firing at a target in the Atlantic, "nine of Palliser's "chilled shot broke up before reaching the target, at distances varying "from close alongside to 500 or 600 yards. One of these is supposed "to have broken up before leaving the gun, as it was seen to scatter "close to the ship. The gun from which this shot was fired, was "loaded and fired twice afterwards, but on trying to load the fourth "time the shot would not go home, and on examination the rifling was "found to be slightly damaged. An impression was taken, and the "armourer having filed the groove, the gun is now" 25th January, "efficient. Six of the shot which broke up, were 7-inch Palliser chilled "shot with rounded bottoms, last pattern supplied to the ship in Sep- "tember last. Three were 7-inch Palliser chilled shot of the first "or oldest pattern. I may mention that three out of seven double "shell on being fired, appeared to turn over and over before reach- "ing the target." In consequence of this report, telegrams were sent at once to the Mediterranean and Channel squadrons to discontinue the use of Palliser shot until a new pattern could be sent out.

Since the date of Captain Stirling, R.N.'s report, the acrobatic performances of the 7-inch double shell, referred to by that Officer have been rendered still more lively by placing the studs on which it is balanced *nearer* to one another. As the uniform spiral of this gun admits of $20\frac{1}{2}$ inches of bearing in each groove and consequently of more rapid twist, the wilful violation of common sense committed in this case is, "one of those things no fella can understand."

The Converted 68-pounder.—The experience of this gun is small, and the published reports few. On 10th August, 1870, a converted $\frac{\text{7-inch}}{\text{68-pounder}}$ was fired, at Shoeburyness, with 28 lbs. pellet powder and a 114-lbs. "Palliser" shell. At the first round, it burst violently into seventy-six pieces, which were flung over a rectangle of 580 yards by 150 yards. This frightful explosion could only have arisen in consequence of the projectile jamming in the bore. This jamming would be facilitated by the lateral wriggling and vertical hammering action incidental to the "Woolwich" rifling; and especially so when the projectile breaks and supplies the wedges. The "Cemetery of Suicides" at the Royal Arsenal, doubtless contains many like fruits of the French system of rifling.

In March and April, 1871, we find the converted 68-pounder firing seven Palliser shell of 89·4 lbs., with 20 lbs. charges, of which "1 "noisy; 1 a little noisy; 1 a very little noisy; 2 very noisy, and 2 very noisy indeed." 1 falling 500 yards short. 17 common shell of $64\frac{1}{2}$ lbs. were fired with 10- and 12-lbs. charges. "8 of the common shell have

"been recovered; studs of all are more or less burred on the driving "edges, with the exception of No. 6, the studs of which are all right. "6 of the shells fired (in April) have been recovered; they all have their "studs burred on the driving edges. . . . With high charges of either "R.L.G., or P., the shells are unsteady, in flight, owing to the studs "being partly sheared." In September, 1871, we are told of this gun, "It would appear that at the seat of the shell the grooves are slightly "enlarged, due probably to the use of the service 64-pounder pro-"jectiles, the small studs of which would be touching one side of the "groove when loaded, and be thrown violently to the other side on "firing."

64-*pounder M.L.R.*—These guns all have uniform spirals. Some of the older ones have "shunt" grooving, but all now built or converted are prepared for French or "Woolwich" studs. That the gas escaping above the shot, erodes the bore, hammers and flattens the stud on which the shot rests, and thence leads to the stud being squeezed out of the grooves and over the lands, and hence to great and irregular strains on the gun, to inaccuracies or breaking up of the projectile, is illustrated by the records of the 64-pounder gun. For example, to take recent reports, only: in December, 1869, forty 64-pounder shell were fired by the "Excellent" without rear-studs, and most of them turned over and over. The Acting Superintendent of the Royal Laboratory reports of the shell picked up that "he believes it has overridden the rifling "altogether and come out on the lands. He has tried it in a gun, and "finds that it will very nearly go in on the lands, showing that the "studs had undergone more compression than would have been possible "if they had travelled in the grooves." Colonel Heyman, R.A. "has "examined the shell, and tested it in the pattern gun, and thinks there "is no doubt that it has overridden the rifling and come out on the "lands." The Deputy Director-General of Ordnance questions "whe-"ther harder studs can be safely used in a wrought iron barrel," lest they should spike the lower groove or bur them all. The gun being sent to Shoeburyness, and forty more shell fired, the Superintendent reports of thirty-one recovered:—"From the condition of the studs it is evident "that the turning over and unsteadiness in flight was due to the shearing "of the studs. The studs on the shells, which were steady in flight, are "in many cases almost worn through, showing that there is a very small "margin of strength in the material." In February, 1871, of forty-five 64-pounder shells with double ring of studs recovered at Shoeburyness; in one, the studs appears to have overridden the grooves; in three, as though they had nearly done so; and in the remainder, the studs are so much worn as to indicate an insufficient margin of strength.

In July, 1871, fifty rounds were fired, with three studs of harder alloy to each groove from a wrought iron 64-pounder "shunt" gun. Seven shell were "noisy" or "unsteady," yet we are told that these harder studs "have produced accuracy of shooting to a "remarkable degree, and entirely remedied the defect observed with "shell having copper studs, viz., a tendency to override the grooves." The Superintendent, Royal Gun Factories, states "that the grooves of "the gun are worn by the studs of the projectiles on the driving edge,

"and the metal is slightly burred up the bore." "The firing of the 50 "rounds from the above gun has seriously damaged one of the grooves, "rendering it liable to split." Five soft copper studs are now used for each "shunt" groove, but no more guns are being rifled on this or any other of the Armstrong systems.

Bronze Boat Guns.—Bronze was decided upon as a material for field-guns, but the erosion and wear in the grooves by the gas and the studs rendered two out of three bronze 9-pounders, tried at Aldershot, in 1870, unserviceable. The Superintendent of Gun Factories reports of one, "Metal cut away in bore by the action of gas from 46 to 53 inches "R, to up to L; deepest part ·25-inch. Grooves worn by studs of pro- "jectiles on driving side. Greatest amount of wear from 39·5 to 53 "inches in all three grooves. Gun unserviceable. Rounds fired, 243, "with projectiles, 59 blank." Of the other bronze gun rendered unserviceable, he reports to the same effect in every particular. In the third bronze gun "grooves very slightly worn by studs of projectiles. "Gun serviceable. . . . . These guns were fair castings, and he "believes they are quite as good as bronze guns produced formerly." Bronze had to be abandoned as a material for field guns in consequence of the employment of deep wide grooves, and the concentration of effort upon studs.

It was, at one time, thought desirable to utilise our large stock of smooth-bore bronze 9-pounder field guns, by rifling them to throw 20-pound shell. Two bronze guns were prepared with "Woolwich" grooving, but the studs sheared in firing, and overrode the grooves, the projectiles jammed in loading, the bores showed signs of expansion and erosion, and, after a short series of practice, both guns became unserviceable. Consequently the idea of utilizing our stock of bronze guns, had also to be abandoned owing to the vicious system of studding and grooving. The 7-pounder double shell for iron field guns were "found rather too long for good shooting." (*Ammunition*, part ii, page 96), owing to lack of rotatory power, the studs being only three inches apart, whilst $10\frac{3}{4}$ inches were available for bearing in each groove, which would have admitted of a much sharper twist. The double shell had, consequently, to be reduced.

	Length.	Weight.
From	12·15 inches	13·2 lbs.
To	11·25 „	11 „
Loss by studs	1·9 inches	2·2 lbs.

If a gaining twist be an advantage, why was it not employed to relieve these bronze guns, instead of the uniform twist which is invariably employed with guns of doubtful endurance?

Latest Practice.—After seven years' experience of the "Woolwich" rifling, every new practice table evidences new failures of rotation up to the very latest published. Several of the ablest Artillery Officers, men unbiassed and uncommitted to any system, believe that the "Woolwich" must follow the "Armstrong," and be abandoned as incapable of doing its work, whilst most destructive to the guns.

Powder Pressures.—The accident to the 35-ton gun is constantly referred to an extraordinary pressure in the powder chamber, though nobody explains how that unusual pressure arose, and as the reliance to be placed on these experiments, is open to question, it may be well to state how the pressure in the chamber is gauged.

To ascertain the maximum or initial pressure in tons per square inch in the powder chamber of guns, crusher gauges are screwed into the gun at the axis of the bore at the bottom of the chamber, into the sides of the gun opposite the centre of the charge, and at the front of the charge, and into the centre of the base of the shot. Into these four gauges prepared copper pistons are placed, and the crushing or shortening of the pistons is the measure of the pressure. These pressures are found to vary within wider limits when using R.L.G. than when using pebble or pellet powder in less quantities than 100 lbs. The following imperfect table may help for rough comparative purposes:—

Gun.	Projectile.	Charge.	Tons per square inch presure in chamber.				Observed velocity at 50 yards.	Mean muzzle velocity.
			Gun, axis at bottom of bore.	Gun, centre of charge.	Gun, front of charge.	At centre of base of shot.		
	lbs.	lbs.					feet.	feet.
12-inch, 25 tons..	600	85, P.	18	16·8	..	15	1,290	1,297
		67, R.L.G. .	21·9	17·8	..	19	1,162	1,168
10-inch, 18 tons..	400	70, P.	20·2	20·1	19·9	..	1,373	1,383
		60, R.L.G. .	34·9	30·5	26·7	..	1,304	1,313
9-inch, 12½ tons..	250	50, P.	..	..	..	10·8	..	1,420
		43, R.L.G. .	..	..	..	18·3	..	1,337
8-inch, 9 tons....	180	35, P.	15·4	14·4	13·4	..	1,452	1,468
		30, R.L.G. .	29·7	25·5	21·3	..	1,361	1,375
7-inch, 6½ tons ..	115	30, P.	..	..	..	10·5	..	1,525
		22, R.L.G. .	..	..	..	16·3	..	1,435

The position of the shot in the bore of the gun when the maximum pressure was registered, as also the other pressures experienced at different stages of the shot's progress within the gun were ascertained by firing cylindrical projectiles 180 lbs. weight and 15 inches long, with 30 lbs. charges, from an 8-inch gun, 126 inches long, provided with about 21 gauges inserted in as many holes one inch in diameter in its walls. The maximum pressure with R.L.G. was 29 tons on the square inch before the shot moved one quarter of an inch, and with pebble powder it was only 15·4 tons when the shot had moved 6 inches. Yet, we are gravely told, by theorists, that the velocity of the shot, with R.L.G., is so much greater in that *first quarter of an inch*, when using an increasing spiral than with an uniform one, that the powder chamber must experience a great relief of pressure in that interval of space.

As to pebble powder, even theorists must acknowledge that the spin is given by the uniform twist before the shot reaches the point of maximum pressure. But as guns do not, as a rule, give way in the powder-chamber, but in the grooving and bore, outside the area of maximum powder-pressure, the contention is puerile and unpractical.

Distance moved through by the shot in the gun.	Velocity.		Pressure.	
	R.L.G.	Pebble.	R.L.G.	Pebble.
	feet per sec.	feet per sec.	tons per sq. in.	tons per sq. in.
¼ inch	..	..	29	1·1
1 inch	360	80	18	6·2
3 inches	510	260	15·9	13·4
6 inches	630	460	13·9	15·4
10 inches	780	650	11·8	14·2
14 inches	840	760	10	12·1
20 inches	950	900	8·2	10·1
28 inches	1,060	1,025	6·5	8·3
40 inches	1,160	1,170	4·7	6·2
56 inches	1,240	1,290	3·1	3·8
76 inches	1,305	1,350	1·7	1·9
88 inches	1,320	1,380	·8	1

The relative values of R.L.G. and of pebble powder may be seen by comparing the appointed battering charges for the service guns:—

Gun.	Projectile.	R.L.G. powder.			Pebble powder.		
		Charge.	Muzzle velocity.	Muzzle energy.	Charge.	Muzzle velocity.	Muzzle energy.
	lbs.	lbs.	feet.	foot tons.	lbs.	feet.	foot tons.
12-inch, 25 tons	600	67	1,168	5,675	85	1,297	6,999
10-inch, 18 tons	400	60	1,280	4,544	70	1,364	5,160
9-inch, 12½ tons	250	43	1,338	3,105	50	1,420	3,495
8-inch, 9 tons	180	30	1,330	2,208	35	1,413	2,492
7-inch, 6½ tons	115	22	1,435	1,643	30	1,525	1,854

The 35-ton Gun. (Plate XII.)—The 35-ton gun has not yet passed beyond the experimental stage, but a small crack, about twelve inches long, has occurred in the steel lining at the usual spot, viz., in the bottom groove commencing about 14 inches from its origin, where the stud on which the 700-lbs. shot rested, and was hammered down by the escaping gas. We are, however, without those official records on which I have solely relied in discussing the rifling of other guns. These guns are intended for the "Devastation" class of ships, and if they realize every expectation, may supersede the 25-ton gun, in other turret ships; and as an exceptional gun in broadside vessels. We have to balance the multiplied chances of hitting by employing two pair of eyes in aiming two 400-lb. shell, containing together 52½ lbs. of powder, from two 18-ton guns, against the concentration of effect in hitting with one 700-lb. shell, with 20⅛-lbs. bursting charge from one

35-ton gun. The authorities evidently think that the balance is in favour of concentration of effort.

The 35-ton gun is $16\frac{1}{4}$ feet long and is of Fraser construction, built up of six parts, the inner lining being a steel tube $14\frac{1}{2}$ feet long and $3\frac{1}{4}$ inches thick at the breech, tapering away to an inch less at the muzzle. It has a 12-inch bore, $13\frac{1}{2}$ feet long; rifled with 9 grooves, $11\frac{1}{4}$ feet long, $1\frac{1}{2}$ inch wide and 2 inches deep; the spiral increasing from nothing at the breech, to one turn in 35 calibres at the muzzle. This is the same maximum increasing twist which proved so fatal to the 11-inch shell, and fails to give it, as reduced, sufficient rotary motion. The gun cost about £2,500, and was designed to fire a 700-lb. projectile with 120-lbs. charge from an 11·6-inch bore; but has subsequently been increased to a 12-inch bore. We have already seen, by comparing the 11- and the 12-inch bores in the 25 gun, that though the latter makes the largest hole and has the most powerful shell, the smaller bore gives the best penetration. The resistance of the air is in the proportion of the squares of the diameters; and the facility of perforation is inversely as the diameters. On the other hand, a larger bore consumes more powder and brings less strain on the gun. The effect of increasing the calibre is very apparent in the 25 ton guns, both firing 85 lbs. of pebble powder; but the 12-inch gun throwing a 600-lbs. shot, and the 11-inch gun a 530-lb. shot. The maximum pressure in the 12-inch gun is only 18 tons; whereas in the 11-inch gun it is $29\frac{1}{2}$ tons, or nearly one-third more strain; yet the velocities are nearly alike, owing to the greater consumption of powder in the larger bore. But there is a limit to the extra consumption of powder due to this increase of diameter of bore caused by the length of the gun being regulated by its weight and by the convenience of muzzle loading on shipboard. It is a balance of qualities, a sacrifice of extra shell-power on the one hand, and of extra perforation on the other, whilst the "Woolwich" rifling will not rotate either shell, but causes slightly less sacrifice of shell-power with the larger calibre and shorter projectile. Passing to the accident, we find that before the "incipient crack" occurred in the steel lining, the experimental gun fired the following 68 charges of pebble powder with 700-lb. projectiles:—

With an 11·6 inch bore	.. ..	4	75 lbs.
" "	.. ..	2	100 lbs.
" "	.. ..	16	110 lbs.
" "	.. ..	6	115 lbs.
" "	.. ..	6	120 lbs.
" "	.. ..	1	130 lbs.
		35 rounds.	
With a 12-inch bore	.. ..	6	110 lbs.
" "	.. ..	13	115 lbs.
" "	.. ..	14	120 lbs.
		33 rounds.	
Total with both bores	..	68 rounds.	

Making about $3\frac{1}{2}$ tons of pebble powder and over 21 tons of shot.

Five rounds with 110-lbs. charges have been fired since the appearance of the "incipient crack" without any extension of the injury. The initial velocity reached its maximum as an 11·6-inch gun, with 120-lb. charges, when it was 1,370 feet per second, with a pressure on the powder chamber of 47 tons per square inch; whilst it fell off to 1,346 feet with a 130-lb. charge, though it gave 63 tons pressure on the base of the projectile, showing that the extra powder was unconsumed, or that the exit of the shot was impeded. Artillerists recognise two kinds of powder-pressures, viz., first, that which is general or usual, and which never exceeds 40 tons on the square inch; and 2nd, local pressures, the result of violent oscillations of the ignited gas, the cause and strength of which are unknown. The combined pressures were 47 tons on the square inch with 120-lb. charges in the 11·6-inch bore, but these were reduced to about 35 tons in the 12-inch bore. Suddenly, at the eighteenth 120-lb. charge, the extraordinary internal pressure of 66 tons per square inch was registered in the powder chamber; and the steel tube being calculated to withstand only 55 tons, an "incipient crack" took place in the bottom groove near the seat of the shot. I have not seen all the registered pressures, but those of the last four 120-lb. charges varied from 40 to 66 tons, the initial velocity with 46·8 tons pressure being six feet more than when the pressure was 66 tons. The muzzle velocity and maximum pressures given by the last four 120-lb. pebble-powder charges in the 12-inch bore, with 700-lb. projectiles were:—

Velocity.	Total work.	Maximum powder—pressures at		
		Axis of gun.	Vent.	Projectile.
1,366 feet.	9,059 foot-tons.	46·8 tons.	35·2 tons.	45·4 tons.
1,360 „	8,973 „	66· „	42·6 „	53·2 „
1,334 „	8,639 „	44·6 „	34·2 „	46·8 „
1,334 „	8,639 „	37·6 „	27· „	39·6 „
Mean = 1,348 feet.	8,828 „	48·7 „	34·7 „	46·2 „

The muzzle-velocity and pressures with smaller charges of pebble powder are said not to present the same variety; probably because the effort of the shot to escape from them is more successful. Some of those for the 115-lbs. and 110-lbs. charges in the 12-inch bore, are:—

Charges.	Velocity.	Total work.	Maximum powder—pressures at		
			Axis of gun.	Vent.	Projectile.
115 lbs.	1,316 feet.	8,408 foot-tons.	44·5 tons.	29·6 tons.	42·4 tons.
115 lbs.	1,288 „	8,047 „	22·5 „	19·9 „	18·5 „
110 lbs.	1,272 „	7,853 „	20·1 „	19·7 „	17·2 „

The service charge is, I believe, now fixed at 110 lbs., which, should it give, as is said, 1,300 feet initial velocity, would inflict a total blow of 8,205 foot-tons at the muzzle. Returning to the last four

120-lbs. charges, and the crack, let us ask, why did the greatest pressure give the lesser velocity, if the exit of the shot was not impeded? Why this variation in the powder-pressure at all? As the shot acts towards the powder-chamber like the stopper of a bottle, or the valve of a steam boiler, the first movement of which relieves the maximum pressure, it is evident that this cannot extend along the bore outside the position of the shot at the moment. When the shot moves six inches from its seat, the pressure reaches its maximum, and when the shot passes beyond that point the pressure is relieved. Evidently the maximum pressure cannot extend beyond the base of the shot at that point, and injuries arising directly from such a cause must occur within six inches of the powder chamber. But the crack begins about 14 inches from the chamber, and ends about 26 inches from it. Again, the 10-inch, 18-ton gun now in use to measure powder pressures, which has 18 inch holes bored through its walls, has repeatedly sustained violent R.L.G. strains exceeding 60 tons on the square inch, and is quite uninjured. The question, then, is still in obscurity and remains unanswered:—Why did this sudden increase of the powder pressure take place? Was the pressure in the chamber the cause, or the result of the accident, which occurred at least 8 inches (or, to the centre of crack 14 inches) outside the point to which the maximum powder pressure extends?

Three theories have been started:—

1st, that the bottom stud flattened by the blow above the shot caused by the escaping gas, overrode the groove, causing a squeeze which delayed its exit, and lead to an accumulation of gas in the powder chamber. These shots were not marked before firing, and have not been picked up and examined since.

2nd. That the wabble caused by balancing the shot on two studs, and the irregular action of the powder above it, due to non-centering of the projectile, wrenched out or sheared the stud and set up a motion of the shot across the bore, which enhanced the difficulty of its escape.

3rd. That pebble powder developes some new quality when ignited in 120-lb. charges which it does not possess when fired in quantities of 100 lbs. and under. This new quality is assumed to consist, 1st, in variable and uncertain pressures, and 2nd, in allowing the shot to proceed further out of the bore before the maximum pressure is registered. Now the centering ribbed 7-inch shot attained, with 2° elevation, Admiral Key's extreme fighting of 1,500 yards range with 20 lbs. of powder, whilst the studded French or "Woolwich" one required 25 lbs. to do so. Supposing those proportions to hold good with large calibres, the 700-lb. projectile, if provided with centering ribs, narrow and shallow grooves, and a uniform twist, would be thrown with the 100-lb. uniform-pressure pebble powder the same distance that it is now thrown with the 120-lbs. erratic-pressure and self-destructive charge, and so the "incipient crack" would not have arisen.

Naval loss.—In dealing with the question of rifling, I have set before you, almost exclusively, official facts. These show that we are sacrificing much of the efficiency of our magnificent guns to a vicious system, in which the effort of rotation is concentrated upon the smallest possible

bearing, that small bearing being necessitated by an increasing spiral, and that increasing spiral being opposed to recorded experiments, the most fatal suicidal results being those obtained where the purest form of gaining twist is employed. There has been an utter failure to secure adequate rotation from the service system; and to the fallacious theories on which it rests, we can trace in official records, loss of practical utility in every gun from the 9-pr. up to the 35-ton gun, and, that, whether constructed of bronze, iron, or steel. As a naval question, it especially concerns us, not only because the non-penetration of a single projectile owing to its wabbling may be a most serious matter in action, and the disabling of a gun by its own shell, be fatal to victory; but because we have permanently crippled the power of our shell by concentrating upon a small and weakened portion of their walls the whole effort of rotation. The common shell proposed for the 12-inch 35-ton gun contains only 20 lbs. 1½ oz., instead of the 45½-lbs. bursting charge in the original 12-inch common shell for the 25-ton gun. Again:—

Pattern.	12-inch, 25-ton gun, common shell.				11-inch, 25-ton gun, common shell.				10-inch, 18-ton gun, common shell.			
	Length.		Weight.	Bursting charge.	Length.		Weight.	Bursting charge.	Length.		Weight.	Bursting charge.
	Body.	Total.			Body.	Total.			Body.	Total.		
	in.	in.	lbs.	lbs.	in.	in.	lbs.	lbs.	in.	in.	lbs.	lbs.
Original	23·85	36·15	600	45½	26·525	37·6	530	40	..	33·8	400	32
Present	17·8	30	495	35	16·425	27·5	402	24·2	22·56	32·5	400	26¼
Lost by studs..	6·05	6·15	105	10½	10.1	10·1	128	15·8	..	1·3	..	5¾

Variety of Projectiles.—Great variety of projectiles are objectionable in military operations, chiefly because of the difficulties of carriage; but in naval actions, chiefly because it is not always possible to say when loading a gun what sort of vessel it is to be fired at. We have two Palliser projectiles, with chilled heads, alike in weight, and nearly alike in all other respects, viz., the cored shot, and the shell, the cavity in which is nearly the same size. The Palliser shell, moreover, is not provided with a fuze, so that its bursting after penetrating the unarmoured portion of an iron ship is doubtful; and after penetrating the unarmoured portion of a wooden ship its *not* bursting is certain. The present Director-General of Naval Ordnance thinks it best "to retain "only one nature of armour-piercing projectile, viz., the present pattern "shell, at east for 10- and 12-inch guns." To this, I would add, that a concussion fuze should be employed, without which the "Palliser shell" does not burst when hitting the unarmoured portions of ships.

The common shell is the more generally useful projectile; and it is most pitiable to observe how its efficacy is sacrificed, owing to the

impossibility of giving adequate rotation, not only to shell of proper powder capacity, but to any projectile whatever with an increasing spiral and consequent short bearing.

We have also "shrapnel shells" which are not to be used under 500 yards, and "case shot" which are not to be used over 400 yards, a space of impunity 100 yards broad, existing between. As hostile naval forces are not always stationary, distances may vary between the loading and the firing of the gun, thus, introducing a further complication, which we commend to the attention of naval gunners.

In conclusion, I am sensible of having omitted the consideration of many most important matters in connection with "naval gunnery," but I have thought it better to concentrate attention on the questions of endurance, both of the gun and of the projectile, and of the powder-capacity of the latter, so far as those are affected by the mode of rifling, and of the relative penetration as measured by the initial velocities of similar projectiles, these being essentially naval points; and to support the views expressed by quoting the *ipsissima verba* of official or authoritative documents. This has led me to dwell on particular points at greater length than if I had merely placed before you my own unsupported opinions. I invite my naval brethren especially to the careful study of the facts produced, in the hope that the result may conduce to the honour and to the defence of our common country, and to the well-being of that noble profession to which all my powers of mind and body were devoted for twenty-five years, and in the service of which I had once fondly hoped to have spent the best of my days. Whatever Orders in Council may determine, depend upon it, that ignorance is not the handmaid of modern seamanship, but that an intelligent study of all sciences underlying the naval profession is a "*sine qua non*" for the efficient commanding of modern war-ships by those to whom the country must entrust its "*outer line of defence.*" Amongst the foremost of these sciences is that pertaining to *artillery*, the principles of which, notwithstanding the other great improvements introduced by the two successive Directors-General of Naval Ordnance, are altogether ignored in the theoretic education of even gunnery officers. Until ignorant impatience of such theoretical studies is banished from the navy, we must not wonder if—

> " blind and naked ignorance
> " Delivers brawling judgments unashamed,
> " On all things all day long."

Whilst we must expect, despite our greater experience, to be far behind military gunners in information, both in the opinion of our own more intelligent members and in that of the world; and that our opinions should carry small weight in the choice of the weapons which we receive, almost unquestioned from, confessedly, able and learned landsmen. Let naval gunners but add to their experience, knowledge; then, and then only, will they be competent to distinguish between false surmises and true principles, and to share with talented Artillery Officers the responsibility, the labour, and the intelligence required to perfect our magnificent guns, so shall we—

" . . . . . send forth
" From far, with thundering noise, among our foes
" Such implements of mischief as shall dash
" To pieces, and o'erwhelm, whatever stands
" Adverse."

Would that I might truly add—

" Nor long shall be our labour; yet ere dawn
" Effect shall end our wish."

Captain SELWYN, R.N.: Gentlemen, I should have waited for some expression of opinion from those who have been more recently acquainted with artillery questions than I am; but the Chairman has induced me to stand up. That being so, and not having the pleasure of seeing to-night Captain Scott, whose name has been so frequently and so honourably mentioned during the most able lecture Captain Dawson has given us, I feel called upon to do the best I can for the tenth year in defence of a system which I, in common with Captain Scott and others, have urged against every other system of rifling known. Not because we had a particular fancy for that system; not because we were partisans of a particular system, but because we saw that the involved principles were those of true mechanics; because we knew that where you throw a large amount of friction on a small surface you cannot get a satisfactory effect; because we foresaw that the immediate result of soft studs of a small area being driven at high velocities, must necessarily be, the bruising of the studs, probably the breaking up of the shot, the destruction of the gun, and the loss of all accuracy. These results have been put before you by Captain Dawson in the most lucid manner. You see, very clearly now, how it is not sufficient that we should rely on those vague theories which are supported by persons who, not being themselves artillerists originally, only become so after a certain time, and by that popular process of the present day, the method of trial and error, in other words, the trying of all possible ways of doing the thing wrongly, before we arrive at, or consider even the right. I think, had we resorted even to the great body of engineers of England, they could have told us from their experience of steam machinery;—and they did in other institutions tell us pretty nearly,—that we were proceeding in the wrong direction, when, first, we relied on the attachment of lead coating to iron shot; when, secondly, we relied on putting small holes in shells which were not intended to break up before the powder charge acted upon them, and then caused them not to break up at any other than the weakest points; that we were not proceeding in the right direction again, when we adopted all sorts of forms of building up guns, without considering closely and accurately,—as we have not yet done,—the true principle of building guns by casting; I say, even to-day, that in Russia they are ahead of us in this question. They have taken the common cast-iron gun; they have steeled the inside by a very simple process; they have reduced the outside to the condition of wrought-iron; and they have, thereby, secured the true mathematical conditions of strain under which iron, whether it be called steel or iron, can best resist the strain to which we propose to submit it. We prefer, in cartridges, resorting to a little bit of iron, a little bit of brass, a little bit of tin, a small quantity of pulp, and several other things, to the simplicity of stamping from sheet metal. In guns we prefer to resort to the laborious process of building up sundry large bits of iron and steel, to the simplicity of a well cast and perfect gun. I do not think with Captain Dawson that we have the best guns; I should be very sorry to think so. I think it would be a very great stain on our mechanical knowledge if we did not know how to put metal together, and so to temper it that it should receive and resist its proper strains, without turning up separate parts in the lathe, and putting them together. I do look forward yet to the time, when even the guns will be improved. But, to pass from that subject altogether, to the more legitimate subject of the lecture, that of rifling, I do not think it needs very many comments on my part to point out that Captain Dawson has arrived,—and he has proved to you that he has arrived, on the mere showing of official records,—at the fact, that we ought not to have rejected, in favour of a foreign plan, which professedly only imitated in a certain degree the "centreing of the shot," and the true

rotation which was given by Captain Scott's original plans—plans carefully thought out by an educated and highly intelligent Gunnery Officer of great experience; that we ought not to have passed through by "trial and error," the lead-coating and the multigroove system, the shunt system, and the polygonal system, which I have often spoken of in this theatre. I have great respect for Sir Joseph Whitworth as a mechanic; but not for him as an artillerist. I happened to be in Brazil the year before last, and a Brazilian Officer there, the best authority they have on guns, gave me the results of his experience of the Whitworth guns. He said, "The gun has never been fired against an enemy, but has killed twelve of our own men." Now, that was done simply from the fact that, as even such a mechanical authority might be expected to do, Sir Joseph had ignored the fact that in these curiously constructed grooves, the discharged powder was very likely to leave sparks. It did so leave sparks, and in loading the gun blew the gunners away from the muzzle. But this is nothing to what follows as a consequence. I must draw your attention to the fact, that the whole of Captain Dawson's lecture has shown us, that those tools on which we have been in the habit of relying, on which I am sure Sir George Sartorius will bear me out in saying, he has always relied without the slightest fear or the slightest care, now fail us. Formerly, if we threw our guns overboard for a year, and took them up again, they were as good as they were before. If we subjected them to all kinds of malfeasance in loading, by Jack's anxiety to put a great amount of metal into his enemy, it did not matter what we did to them, they were always good. But here is a picture before us, in which we see a fleet manned and sent to sea, exercising the seamen in the use of these guns; and the very exercise has broken down the guns before they came into action. And we are asked to form the first line of defence! with ineffective guns—with guns in which no naval gunner can put his faith. Is not this a picture which is worth thinking of, which conveys facts worth working at closely and consistently? Is it not a thing in which there should be no concealment on any part, no desire to conceal? I do not see anything more expressed than these doubts which, according to Captain Dawson, have been thrown out, whether the powder may not have done it, or whether anything else might not have done it, except the thing that did do it. We want to know what did do it. We do not want to have any doubt on the subject. We want exhaustive experiments, easily performed, with the acres of guns of all natures which, to use a compendious term, are now obsolete. We should really try experiments to find out what ought to have been done. But we do not try these experiments. We try to find out how many things ought not to be done. "Trial and error," that is our constant course. It has been so with iron ships, and it is so with guns. Until we honestly confess that studs picked up by dozens are not in a satisfactory state, and should not be used, as compared with ribs that have never shown such failures, we shall never go ahead at all. We shall be exactly in the state, when war breaks out, of trying experiments, experiments thoroughly inconclusive in themselves, as widely wrong as those are likely to be which are based on a theory as to increasing the spiral. If I was to go into theory, I would beg you to observe that, as a shot starts from a position of rest, by progressive increments only acquiring the terminal velocity, the spirals ought on that theory to be decreasing, because the shot is passing over more feet in each moment of time, from the moment it starts to the moment it leaves the muzzle; and for the twist to remain the same proportionally, the spiral of the rifling ought to decrease rather than increase. Mathematically speaking, that would be the case. But we are contented to have less mathematical correctness if we can ensure greater general results in practice. That result in practice is shown wherever you only seek a moderate effect as to great range. And great range has run away with an enormous number of people, both in small arms and in artillery. It is, I do not fear to say, one of the greatest mistakes of the day. It is a thing which will lead to the expenditure of more rounds of ammunition uselessly, than anything else. It is a thing which will lead to more demoralisation of troops on land, and more uncertain work at sea, than anything you can do. Do not go in for it. Hit your blow hard at a short distance. Wait until you have got within that distance. Do not make the mistake of allowing each man to hope he may hit a mosquito five miles off. I cannot speak too strongly on this subject, for I feel that the whole

results of our gunnery depends on the adoption of the most simple principle of rifling. I am even almost inclined to say, that the smooth-bores,—take them out and out,—will beat in practical results, the rifled gun with the very best range. I want to see the rifling that will give us, under all conditions and at all times, quite equal results with the smooth-bores. I am not prepared to say that you can fire great powder charges contained in very long shot with great accuracy at very long ranges, from the smooth-bore; I know that you cannot. But I want you to consider the balance of advantages, and to consider it closely. I want you to consider why it was that rifling having been known, having been tried many hundred years ago, was abandoned, and the smooth-bore was brought back. It was not done for nothing. We must not credit our ancestors with such a great amount of folly as to suppose they did all these things, realised an advantage, and then abandoned it. It was because they did not find the advantages which were theoretically to be obtained. And not among the least of these, remark, is that ricochet firing which has been so often adverted to here, and which has not certainly been obtainable from the best rifled gun, whether on land or at sea. I want the gun which will stand the most hard wear, the most wear and tear with the least damage, which will give the best general results, and which will be ready at all times for action; and which will not be probably liable in the heat of action to a report from the Gunnery Officer to the Commanding Officer, "three guns are disabled, and you have only got four." Just picture to yourself the Commanding Officer of a ship receiving such a report. What would be the feeling on board one of our finest ships if such an accident, as has been brought before us, were to occur in that ship? How should we face our country? Would they believe us when we told them that, because you gave us that gun, we were not able to fight a good action! They would say, "you ought to have fought with your teeth, you ought to have done anything." But, unfortunately we are but men, and even at sea we cannot do more than we can do. I want to press this strongly on the Institution, that it is only by means of exhaustive experiments that these matters can be decided, that such exhaustive experiments must necessarily cost money, and ought to come under the observation of the very best persons to be found in the country on such subjects; that no man ought to be admitted as an authority, nor his views entertained, who has once been proved to be the happy possessor of a petted fallacy. Neither excuse nor ingenious theories ought to be admitted when a man has proved that he did not know how to do it. Let us find out by close examination those men who can do it. Let us encourage them. Do not let us cut down £12,000 to £2,000 yearly, for experiments, and then find fault with the results of an experiment on an ironclad that cost half a million. Do not let us say that the economy of "modified pens" is to be carried into the guns of the Navy. Such things may be worthy of an economist who only sees things through the eyes of a commercial man. They are totally and utterly unworthy of the patriot who seeks the honour and the glory of his country, who says that no expenditure is useless, or is thrown away, if the results obtained, will ensure the lasting glory and status of this country. This has not so been; this is not being done. To-day money is grudged for experiments; it is cast away with open hands for the purpose of vague theories on human perfectibility. I do press on this Institution the fact that they are in possession of the field, if they choose closely and strongly to urge on the Government of the day, that to practice alone, not as distinct from, but as part and parcel of science, they must look for the carrying out of the work of the country; and that cautious experiment combining the two cannot be too sedulously encouraged. Then, I say that this and other institutions may so insist upon this, may so bring it before, and home to, the people of this country, that no Government can resist the tide of experiment that would set in, and which would repay us fully in its results.

Captain Colomb, R.N.: I would suggest that if there is any gentleman here, who knows the other side of the question with regard to the Scott gun, he should give us his views. At present we have only the strongest arguments and the strongest facts quoted to us on one side; and a member like myself who is not very conversant with these subjects, is left in a semi-amazed state on hearing only that one side. There must be another side, I imagine of the question; and, I should say,

there must be some gentlemen present who could give it to us. In the year 1859 or thereabouts, I happened to be at Shoeburyness, when the first rifled field gun on the French pattern was tried. It was tried against the Armstrong gun in my presence, and there was nothing but the most complete condemnation of the stud-system shown on that occasion—the system which I have since seen adopted. I merely state it as a fact which came under my own notice.

Commander DAWSON: It is somewhat disappointing, after spending some three or four months, on what has been a very interesting occupation, to find when one comes before an Institution like this, composed of a number of naval and military officers, that one's labours are so far not appreciated, as that no person thinks it worth while to take the opposite view. It is a little disappointing, because I quite agree with my friend Captain Colomb, that there ought to be another side; I know there is another side, but it is not a side which I care to take up. It is a side of speculative hypothesis, and delusive mathematical formulas, the elements of which are pure assumptions. It is well known to mathematicians, that erroneous premises will lead to the most astoundingly fallacious results. There is indeed, a very simple algebraic equation by which it can be clearly proved that nothing is equal to anything. It is with the premises alone that I have dealt. In doing so, I have confined myself simply to *well-ascertained facts*, authenticated by their appearance in official publications. There are speculative opinions in those publications, but I have not chosen to quote them, because those opinions are sometimes based on insufficient evidence, and are often opposed to one another, and to the facts appended to the same documents. There are in the numerous official Reports, which I have studied, Tables of Practice, issuing from Shoeburyness; which I take to be absolutely true. For example, looking into the Report of the only heavy gun competition in this country, which was written seven or eight years ago, when there was not the amount of experimental experience and information on the subject which we have now; I find that the prophetic utterances which were then issued, turned out altogether false, being falsified by the events. That being the case, I have not deemed it worth my while to quote those opinions, or to contradict them, as I did not wish to hurt anybody's feelings by referring to false prophecies. But in justice to the other, or speculative side, it will be seen that in the Report of the 7-inch gun competition (1865), the opinions contrast extraordinarily with its own facts; and the prophecies with the events. Contrast for instance Art. 9, p. 3, in which both the Scott and the French systems are regarded as equal in endurance, with the "Report of the Inspector of Ordnance," page 20–21, where it is said the French gun, "should in future be fired under precaution," and the details of the injuries are given; whilst of the Scott, "there is no apparent expansion in bore, nor alteration in the dents since last examination." Contrast again the prophecy p. 3 that "there need be no fear of the breaking down "of the grooving by the abrasion of the studs," with the constant occurrence of this wear. Contrast the ease of loading reported p. 3, with the Shoeburyness Report p. 26, where a metal rammer had to be repeatedly used, to force home the French shot. Contrast the statement Art. 20, p. 6, that, except in firing round shot, the French gun "is in every other respect equal or superior to" the Scott; with the statement Art. 13, p. 4, that "the French system has somewhat decidedly the "lowest velocities," striking a muzzle blow 133 foot-tons less than the Scott; and, Art. 21, p. 7, that "the French gun is but inferior up to 5°," *i.e.* up to 2,500 yards, or inferior up to 1,000 yards beyond useful fighting distance; and with the statement, Art. 6, p. 15, "the single point upon which the Scott system may be practically "superior to the French is in the cheapness of its projectiles," the Scott shell being £80 per thousand and the shot £92 per thousand cheaper; and with the Report of the same Committee that "Scott's projectiles have the further merit of being of "convenient exterior form, easy to pile, but little liable to injury and simple in "manufacture;" and "Scott's form is the most advantageous for a shell in respect "to capacity, the Committee give precedence in respect to the efficiency of the projectile, to Commander Scott." But the 7-inch guns, says the Report, Art. 22, p. 7, are "essentially shot guns"!!! Compare the prophecy, "nor do the Committee think "it probable that any disparity will appear in their performance with longer projectiles," with their report, 4th August, 1865, that the 7-inch double "shell roll "considerably, owing to their great length." Contrast the statement Art. 13, p. 18,

that the advantage of the increasing spiral "can best be realized with a short bear-"ing on two points," with the Shoeburyness Report p. 40, and again p. 42, that "the recovered shells show that the small stud did not touch the driving edge of "the groove;" and with the now well ascertained fact that the guiding studs do not share the effort of rotation with the driving ones, but simply serve to mitigate the wriggling motion of the projectile in the bore. Contrast the statement Art. 4, p. 15, "the shells recovered after being fired from the other two guns were "apparently uninjured," with the Shoeburyness Report, p. 36, that "40 French "shells have been recovered," of which 28, or 70 per cent., had their studs "moved" or torn out, whilst, p. 55, six loaded Scott shell were re-fired which "were recovered "shells, and fired in the presence of the Ordnance Select Committee, none of them "burst," and in the previous cast-iron rifled 32-pounder competition, Scott's recovered shells were fired over again an average of six times. Compare again the statement, Art. 4, p. 15, that "five of the recovered shells were subsequently fired "full of powder, from each of the two guns," with the Shoeburyness Tables, p. 36, which show that the only five loaded French shells fired, were original and not recovered projectiles. Again, contrast the eloquent and eulogistic prophecy upon Sir William Armstrong's "shunt" system Art. 16. p. 19, with the actual event, viz., its utter abandonment. See how the arithmetical errors, in the Committee's summary, pp. 5, 8, 9 of the Shoeburyness Tables of practice, pp. 24, 45, &c., invariably favour the French gun; and how the delusive ranges at 4,500 yards are meaned with those at fighting ranges, p. 5; and how the ranges obtained with 110-lb. shot, (which weight had been fixed "in order that the very best shooting qualities of the guns might be developed,") are omitted from the body of the Report, except those with 12-lb. charges, the superiority of which in Scott's gun was least overwhelming, but without a comment as to Scott's enormously greater force of blow at the muzzle. A consideration of these things will show why I discard opinions so opposed to one another and to the facts on which they are supposed to be based. Truth can only be based on fact. I beg those who may be seekers after gunnery truth, not to rest on opinions however authoritative, but to go back to the experimental data on which they are based. Dogmatic gunnery is not scientific gunnery—the one is a system of guesses, the other a digest of accumulated experiment. Science formulates existing laws of nature, but it does not create them. There is "a science falsely so called," but true science is simply the art of expressing absolute ascertained facts in precise language,—it is not guess work, but known truth. Look, then, for facts, and not for guesses.

I am sorry that the extreme length to which the subject led me, obliged part of the lecture to be given *viva voce;* but when it comes out in print those who will do me the honour to read it, will find that throughout, step by step, it consists of a string of quotations from different official reports, giving with them figures, which it is no use reading out, as people cannot follow figures with their ears, though when seen with the eyes, they will be understood and appreciated. Now, referring to Captain Selwyn's remarks, my statement that we have the most magnificent guns in existence, does not prejudice the question that better guns might not hereafter be found. On that I express no opinion. I came here to state established facts, not prophetic opinions. I have searched, as far as I can, for authenticated information of those systems that have been officially tried under like conditions, conditions that I look upon as reliable; and such facts have alone been brought before you to-night. But I have rejected those opinions of which I cannot actually find the basis of well-authenticated experimental facts on which they are founded. It is not sufficient for me that it is reported, I do not care on which side it is, that somebody or other has produced a magnificent gun in this country or in some distant land; I must have the fact authenticated in some way by recorded experience before relying upon it. Otherwise I should have gone into no end of speculative reasoning, which would have taken a whole volume to deal with every debateable point. Another point referred to by Captain Selwyn was that our smooth-bore guns show greater accuracy when in lively motion at sea than our rifled guns. That is a well-established and undoubted fact. But when we come to inquire why the fact is so, we must not look inside the guns for the cause, but outside them. It is ascribable to the sighting,

and to ignorance of the distance. I was not able to go into the point to-night, but you will find it explained in my paper that the sighting of rifled guns is most inimical to accuracy. As there are military men present, I may, perhaps, be permitted to explain that the seaman gunner aiming a gun at sea must stand six or eight feet behind the rear-sight. And in order to see the object in line with the outer sight, his eye must pass a certain vertical distance above the rear-sight. The amount of vertical height between the rear-sight and the line of vision, depends upon the state of the weather and upon the motion of the ship. When the ship is steady, in cloudy weather it will probably be $\frac{1}{10}$th or $\frac{2}{10}$ths of an inch. When the ship is very lively, it may be half an inch. At all known distances, all considerable errors in shooting at sea are dependent upon the height that the line of vision passes above the rear-sight. Now, let us take a given vertical height of visual error, say half an inch. The effect that half-an-inch will have upon the range, depends upon the distance between the rear-sight and the fore-sight. Bring the fore-sight within a few inches of the rear-sight, and that vertical half-inch of visual error will cause some thousands of yards increase of range. Push that fore-sight away as far as you possibly can from the rear-sight, and the same visual error will mean at 1,000 yards range, perhaps, 90 yards error with a 68-pounder smooth-bore. Put then, a 68-pounder alongside one of our beautiful nine-inch 12½-ton guns on the same lively platform, and let the same vertical visual error of half-an-inch be made with both; it will cause at 1,000 yards distance, an error in range of 380 yards with the rifled gun, but only 90 yards with the smooth bore, if the muzzle sight be employed. That explains a great deal of the mystery. Rifling has comparatively little to do with inaccurate shooting at sea; it is simply a matter of knowledge of the exact distance, and a better system of sighting. Captain Selwyn has referred to the absence of intelligent, painstaking, and exact experiments conducted by men of science, so as to lay the foundation of true principles, and substitute scientific gunnery for that dogmatic system of guesses, which forms the ground-work of so much artillery teaching, and of that "rule of thumb" which constitutes the most important artillery formula. The necessary experiments to determine the merits of the increasing and the uniform spiral, on which the whole ruinous short-bearing system hinges, could be tried at a very small expense. Let two or more 25-ton blocks be bored up to nine or ten-inch bores, one with *uniform spiral*, the other with the *increasing spiral*, and others with various lengths and kinds of bearings, and let any number of experiments be tried. And after the experiments have been exhausted, put in the boring machine, and bore them up to the proper service calibre of eleven inches. The cost would be small, consisting solely of the actual powder and shot used, and the difference of expense in twice boring out instead of once, which would be a mere trifle. A few thousand pounds would exhaust the whole outlay from beginning to end. The proportion which this outlay bears to the three million expended on the now obsolete Armstrong lead-coated system, to the large sums sunk in the "Shunt" system, and to the millions which have been lavished during the last seven years on the yet most suicidal French system, is exceedingly small. But we want the intelligence, the patience, and the scientific impartiality which is to direct such experimental researches. So long as people are content to go on theorising upon hypothesis, for which they have not the slightest basis whatever, they can't understand the necessity for exact comparative experiment, and they won't take the trouble of laying a sure foundation of experimental facts. Captain Selwyn has also referred to the part that this Institution might play in questions of this kind. I think we ought to be reminded that it was this Institution which saved the country from squandering many more millions of money on false systems of artillery which would most assuredly have stranded both our land and sea forces in national disasters. The leading and active part which this Institution took in undermining, and finally overthrowing the lead-coated system, and the "shunt" system, should not be forgotten; and I hope that this Institution may also help to overthrow the present suicidal rifle system, which has disabled eleven guns on shipboard in the last three years, besides a larger number self-destroyed at Woolwich and Shoeburyness and now lying in the suicide's cemetery unburied, though not unwept or unsung, at the doors of the Royal Gun Factory at Woolwich.

The CHAIRMAN: I should like to ask one question. If I understand you

rightly it would be quite possible to improve, and make as perfect as you see your way to, all our existing guns, by taking out their steel tubes, boring them up, and rifling them on some other principle?

Commander DAWSON: The cost of doing so to the 35-ton gun would be about £700. It would be much less for smaller guns.

The CHAIRMAN: The original cost of the 35-ton gun being how much?

Commander DAWSON: £2,500 at arsenal prices. As you buy it from Elswick, it would be about £3,500.

The CHAIRMAN: Gentlemen, I am sure you will return your hearty thanks to Captain Dawson for the very able paper which he has read to us to-night.

Evening Meeting.

Monday, April 15, 1872.

ADMIRAL THE EARL OF LAUDERDALE, K.C.B., &c., &c., in the Chair.

NAMES of MEMBERS who joined the Institution between the 9th and 15th April, 1872.

ANNUAL.

Matheson, Duncan, Lieut. 6th Inniskilling Dragoons.
Miles, Thomas G., Major North Durham Militia.
Reasch, F. Carne, Lieut. 6th Dragoon Guards.
Farrer, W. D. M. C. P., Lieut. Grenadier Guards.
Wandesforde, C. H. B. C., Lieut. Grenadier Guards.
Aitken, W. D., Col. Royal Artillery.
Stopford, Hon. F. W., Lieut. Grenadier Guards.
Marsham, H. S., Lieut. 60th Royal Rifles.

MOUNTING AND WORKING HEAVY GUNS AT SEA.

By Commander WILLIAM DAWSON, R.N.

THE last seven years have witnessed a marvellous revolution in the weight of the guns carried by H.M.'s ships, in the carriages upon which they are mounted, and in the appliances by which they are worked. Seven years ago, several of the ablest naval captains officially stated in their printed evidence before an Admiralty Committee, what was the general opinion of the whole Navy, that it was impossible to work guns over six tons weight on the broadsides of ships at sea. Yet at this moment 25-ton guns are being worked in a seaway on the broadside, with far greater ease and security than 25-cwt. guns were at that time. More remarkable still, the mechanical power is so increasingly applied, that the man-power essential to manœuvring heavy guns at sea, is in an inverse ratio to their weight. Thus, in an emergency, apart from the loading, four men can work the 25-ton, 18-ton, or 12-ton broadside gun at sea, by taking the several duties successively; whilst eight men can hardly manage the rope-worked $6\frac{1}{2}$-ton gun; and under similar conditions of heel, 14 men have enough to do to jerk the $3\frac{1}{2}$-ton 64 pounders about on truck carriages. This reduction of human labour is accompanied with a corresponding rapidity, ease, and regularity of movement, highly conducive to accuracy of fire and to safety; whilst it exposes far smaller bodies of men to the contingencies of war both on the battery and upper decks.

Ten years ago, when I ceased to be senior Lieutenant of the School of Gunnery at Devonport, the standard broadside guns were those of 58 cwt. and 65 cwt. worked on antiquated truck carriages by fourteen men. Those who have, in former days, worked the officers' gun at first quarters in the "Excellent," may remember the exhaustion inci-

dental to the jerking action, both on the handspikes and on the tackles, in dragging the gun round the sweep piece to different bearings beyond the "wooding" point. On the "Cambridge's" broadside was a 95-cwt. gun on an equally barbarous rear-chock carriage, which 22 stalwart seamen, urged to their utmost powers, vainly strove to train with rapidity equal to that of the 65-cwt. guns, and after breaking most of the gear, the attempt had to be abandoned. The principal slide gun of that period was the 68-pounder of 95 cwt., a good shooter, most unsafely mounted. A single rope on either side, and a single whip in rear, formed the running-in gear. The carriage was not tied down to the slide, nor was the slide tied down to the deck. The compressors did not control the movements, except when set up for actual firing. And when the ship was in lively motion at sea, it was highly dangerous to cast off the lashings so as to use the gun. For, whilst in the fore and aft position, the gun might capsize or fetch way; and in the attempt to run it in, to shift the pivots or to load, there was a constant peril that in a quick roll it might break loose from all control. These slide guns, therefore, were seldom used in a seaway, and when they were, it was no small relief to all concerned when they were again firmly lashed to the decks and bulwarks. Captain Preedy's evidence, in 1865, as to similar slides for the $6\frac{1}{2}$-ton guns in the "Hector," is applicable to both weapons: "the other day we had great difficulty in running the gun in with 22 "men on the train whips and tackles attached to the carriage, the ship "heeling over 6°; but the fact of firing the gun, I have no doubt, "would have brought it in. Why I alluded to running in was this, "the ports of these iron ships are low, and if you get a gun out and "cannot get it in again, it would be a serious matter in a sea-way, for "you would ship such heavy seas that it would become a very serious "matter." The present Rear-Admiral G. T. P. Hornby stated, in 1865, that Captain G. O. Willes, R.N., having cast loose for exercise in a sea-way, a $6\frac{1}{4}$-ton gun so mounted, the gun was unmanageable, and the men were afraid to go near it. Any experienced naval artillerist who will carry his thoughts back seven years, will wonder at the hardihood of Captain Willes in attempting, in a sea-way, to cast the lashings off the slide guns of that period. So unsafe were the gun slides then in use, that ships so provided were virtually disarmed by a moderate swell of the sea, as reported by the late Admiral Warden and the Captain of the "Lord Clyde," so late as 1866. Nor need we wonder at nor blame our talented military brethren for perpetuating such rude and antiquated truck carriages, and such unsafe gun-slides. Seamen and the Admiralty knew by sad daily experience the results, but soldiers and the War Office provided the appliances. Had our able military providers had a week's experience at sea with their own contrivances, they would no doubt have speedily devised a remedy; but they were dependent for information at second-hand from seamen who, though handling heavy ordnance every day of their lives, are technically supposed to be supremely ignorant of artillery, their carriages, and stores. It speaks well for their capacity, that the War Department which has no interest in the Navy, and their military subordinates who have no knowledge of its specialities, should have made so few bad guesses.

When, however, it was proposed to mount guns on ship-board over six tons weight, the problem of safety, facility, rapidity, and accuracy of motion in all directions and in all weathers, with perfect control of every movement, lateral, vertical, and longitudinal, was quite beyond the ordinary ken of seamen or soldiers, mechanics or engineers. So great a mechanical authority as Mr. H. D. P. Cunningham, R.N., stated in this Institution* in 1864, "it has often been remarked to me "by officers, that they always dreaded casting loose their 68-pounders "(95 cwt.) at sea, and were always delighted when the guns were "again secured. If, then, this anxiety existed in regard to guns of "between 4 and 5 tons in weight, how great must it be, or rather will "it be, when dealing with guns three times heavier, with probably all "the embarrassing accompaniments of wet, slippery decks. Can we "continue," he asks, "to work our heavy guns by manual power? " . . . Arms of flesh and bone must give way "to the iron arms and sinews of the mighty steam-engine." He pointed out that though 12-ton guns may be worked by 21 men on a level deck in smooth water, it was then, in 1864, doubtful to the best mechanicians if 30 men could control such ponderous weights at sea. Yet, seven years later, four men are found controlling with perfect ease and safety on the broadside at sea, a weapon which, with its slide, is nearly three times heavier than the 12-ton gun referred to, whilst Admiralty Minutes state that ordnance of 35-tons weight, or, including the carriage, about 50 tons in all, can be worked on the broadside with ease. These guns could be managed more safely, with less exertion, by fewer men than that now required for the $3\frac{1}{2}$-ton guns on four truck carriages, and be moved with smooth, accurate, and rapid movements in all directions.

Turret carriages have undergone corresponding improvements. To minimize the vertical opening of the port, whilst obtaining adequate elevation and depression, gun and carriage and slide were bodily raised and lowered by screws acting separately or in pairs, under either end of the slide. Should the altered heel of the ship, or a change of object, demand a sudden movement from the highest elevation given by the port, to extreme depression for the delivery of a plunging fire through the decks of a ram, the moving slides of the turret ships "Wivern" and "Scorpion," would take, in smooth water on an even keel, one hour to alter the elevation of their $12\frac{1}{2}$-ton guns; improvements introduced into the moving slides of the "Royal Sovereign" enables them to accomplish this change, in smooth water, in half-an-hour; alterations made in the moving slides of the "Prince Albert" enable extreme changes of elevation to be accomplished in $2\frac{1}{2}$ minutes instead of 40 minutes. But the great change of all, has been to build the slides into the turrets as fixed strengthening struts or beams—in fact, doing away with slides altogether—and employing a compound pivoting carriage, in which the gun alone is lifted and lowered at its trunnions, and effecting extreme changes of elevation with 25-ton guns

* See Application of Steam Power to the Working of Heavy Guns, by H. D. P. Cunningham, Esq., R.N.; Journal of the Royal United Service Institution, vol. viii, No. 30, 1864.

in the "Monarch" in less than four minutes. The importance of small vertical port area is evident in raising the lower cill higher above the water, limiting incursions of the sea, keeping out hostile bullets, and taking less strength out of the turret walls. The value of rapidity in making extreme changes of elevation will be evident to those who keep in view the manifold services of war ships. Take one recent example:—In September, 1870, a broadside ship, the "Royal Oak," engaged at shell practice, firing at targets 12-feet by 12-feet to represent gun-shields. These were marked on the Rock of Gibraltar, in Catalan Bay, at the heights of 400, 500, and 710 feet. The 8-inch 9-ton main-deck guns could not be fired at even the lowest target at a less distance than 1600 yards, as the marks could not be seen through the ports over the sights. But the upper deck guns could have been aimed right over the rock at that range. Now, if whilst bombarding a battery at such a moderate height as 400 feet, a hostile iron-clad had attempted to ram the "Royal Oak," her broadside guns could have been rapidly changed, in not more than a few seconds, at the last moment from the extreme elevation due to the lower battery, to the extreme depression demanded for plunging fire. But, with their guns on the bottom step to hit these high marks, the turret ships as originally fitted with moving slides, would have taken from 40 to 60 minutes to execute this simple evolution; and whilst it was being executed, those ships would have been unable to fire a shot. Now, considering the brief duration of the critical part of naval actions, and the value of heavy fire at the decisive moment, time must ever be a most important element in naval gunnery. Quickness is not, however, the only important object gained by the substitution of compound pivoting carriages, which do not touch the turret walls, and are not, therefore, affected by any hammering the armour may receive, for they rest upon girder beams below the decks, built into and imparting structural strength to the turret, in all the later ships.

After dwelling on the difficulties which the designers of modern gun-carriages have had to overcome in imparting motion in so many directions to ponderous weights, on an unstable platform, and in controlling their movements when subjected not only to the rapid oscillations of the waves, but to the violent action of their own charges, one of the ablest scientific organs of civil engineers, the "Engineer," remarks, that the marvellous success which has been attained "constitutes one "of the most magnificent triumphs of mechanical engineering yet "seen, if we take into account the limited space and limited power "available;" and "this problem has not been solved by trained "mechanical engineers; on the contrary, so far as the British Navy is "concerned, it has been solved by a naval Officer, Captain R. A. E. "Scott, R.N.," the distinguished gunnery Officer who lately held the office of Admiralty "Superintendent of Gun-carriages." This opinion is endorsed by the most competent naval authority, the late Controller of the Navy, who wrote in an official Minute, dated 4th May, 1869, that "most important benefits have accrued to the Naval Service "through Captain Scott's exertions, and that, without those exertions, "neither 12- nor 20-ton guns would have been successfully worked on

"the broadside of ships." To this I have only to add, that every heavy gun in the Navy, whether mounted in turrets, on turntables, or on broadsides, is partially or wholly mounted and worked on carriages, and with appliances devised by the same officer. Whilst the United States Government took a large sum in last year's estimates for the reconstruction of their 10-inch and 15-inch gun slides, our mechanical carriages and machinery are the admiration of the ablest civil engineers and naval Officers, and are being copied by all the maritime nations of the civilised world. When we recal what a vast and undreamt-of revolution has been wrought by this naval gunnery Officer within the last seven years, we must not be surprised that the present excellence was not all attained at once. Old prejudices had to be overcome, and officials had to learn that a seaman might know how to manage a gun at sea. Each step of progress represents a victory won, not only over a talented* competitive design, but often over an "improving" department, committee, or official.† Until the "piracy" or the "improvement" had utterly failed, the original design was not admitted; and, at one time, so high ran the departmental contention, that it was necessary for the Admiralty to interpose its authority, and order pattern-carriages to be made in a Royal dockyard under their own eye. As it is best to "let bygones be bygones," I refer to what the late Controller of the Navy calls "discouraging circumstances," not to illustrate the personal and professional difficulties which beset the Navy in acquiring the full use of a good invention, but to account for the ever-advancing mechanical progress noticeable year by year in our naval carriages, each advance representing not so much a novelty in design as a battle fought and a victory won; and also to account for the defects and deficiencies to which I shall have to refer in some details of the carriages still in use. What was written by the Controller in 1867 is true, though in a less degree, in 1872, viz., "that "if the plan of constructing carriages and slides proposed by Captain "Scott, in 1864, had been adopted, we should not, in 1867, be stating to "their Lordships that the service slides and carriages are too weak," and, after enumerating the several constructive details, the Controller adds "all these improvements might have been secured for our naval "artillery as early as 1865; but, unfortunately, the view taken by the "recognised department entrusted with this especial duty was opposed "to these plans."

Armaments of Ironclads.—Concentration of fire, that great dream of the most eminent naval artillerists, is now effected, not so much by converging a large number of light guns upon one point, as by concentrating the weight of numerous small guns into a few heavy ordnance, each capable of effecting, with one large projectile, a far greater shock than that hoped for from the simultaneous blows of many small shot. If such concentration was considered desirable in battering

* See Additional Particulars as to his Method of Working Heavy Guns, by H. D. P. Cunningham, Esq., R.N., Journal of the Royal United Service Institution, vol. x, No. 39, 1866.

† Modern Gun Carriages for Heavy Naval Ordnance, Journal of the Royal United Service Institution, vol. x, No. 41, 1866.

walls of wood or stone, it is much more essential in hammering walls of iron. But an idea prevails that the armament of a ship should consist of guns capable of penetrating her own sides, rather than those of hostile ships. Hence we find that the "Hercules," for instance, has very much less to fear from a fleet of iron-clad "Achilles," of 9,694 tons, than from a single unarmoured "Inconstant" of 5,782 tons; seeing that shot from the four 9-ton and twenty-two $6\frac{1}{2}$-ton guns of the ironclad "Achilles" would, at 1,000 yards range, rebound off the sides of the "Hercules," whilst every shot from the ten $12\frac{1}{2}$-ton guns of the unarmoured "Inconstant" would perforate her thick plated antagonist.

The influence which the introduction of machinery for working ordnance at sea has had upon the armament of ships may be understood by comparing the weight and power of the several guns carried before and after its adoption. The "Minotaur," the largest ship in the Navy, is also one of the worst armed. With twenty-two $6\frac{1}{2}$-ton guns, mounted on slow-firing rope-worked carriages, she has only four $12\frac{1}{4}$-ton guns on mechanical slides available for heavy weather. Whilst her sister, "Northumberland," is enabled, by the use of quick-pointing machinery, to carry 68 tons more of artillery, and to work twenty-six heavy guns under all conditions of weather, having only two unsafe rope-worked carriages.

The "Warrior" now carries 10 tons of artillery more than before; yet her offensive power is concentrated in twenty, instead of twenty-eight guns. The "Warrior" can now work twelve guns with accuracy in a gale of wind, and has only eight, instead of twenty-four guns upon unsafe rope-worked mountings.

The "Prince Consort" now concentrates her 160 tons of artillery into fifteen pieces, every one of which can be safely worked in any weather, instead of dispersing it into twenty-four smaller pieces, twenty of which, having rope-worked mountings, were inaccurately worked at all times, and were useless in a sea-way.

The "Zealous" was sent to the Pacific before the value of machinery was appreciated, and is, consequently, the most helpless of our sea-worthy ironclads. Her armament consists of twenty $6\frac{1}{2}$-ton guns on rope-worked mountings, so that, in an encounter with a hostile unarmoured "Inconstant," carrying ten accurately moving $12\frac{1}{2}$-ton guns on mechanical slides, the ironclad "Zealous" would be overmatched in moderate weather, and would, in a gale, be a helpless mark for her better armed, though unclad, antagonist.

The "Royal Alfred" carries, in proportion to tonnage, the heaviest armament of all our ironclads. But her eight $6\frac{1}{2}$-ton guns are unsafely mounted on inaccurately rope-worked slides, and their offensive powers cannot be fully developed. The ten $12\frac{1}{2}$-ton guns can be very efficiently fought by machinery, though they are not so thoroughly effective as the corresponding guns in the "Sultan," which ship has the best mounted artillery in the Navy.

The "Sultan," "Repulse," and "Prince Consort," are the only ships which, being exclusively furnished with mechanical slides, can freely use their whole armaments in any weather, and fully develop their

Broadside ironclads.	Weight in tons.	Heavy guns.			Gun carriages.		Complement of men, &c.	Reports of Captains, &c., on rope-worked gun-carriages in a sea-way.
		Number of pieces.	Total weight.	Tons weight of ship per ton of gun.	Worked by machinery.	Worked by ropes.		
	Tons.	No.	Tons.	Tons.	No.	No.	No.	
"Minotaur"	10,627	26	193	55	4	22	706	Training "tackles are insufficient altogether."
"Agincourt"	10,627	28	218	49	6	22	705	
"Northumberland"	10,584	28	261	40	26	2	705	
"Achilles"	9,694	26	179	54	4	22	705	"Cannot be worked satisfactorily" Scott's running-in chain "is much required." For chase-guns, mechanical training gear "is absolutely necessary."
"Sultan"	9,286	12	194	48	12	...	630	
"Warrior"	9,137	20	202	41	12	8	709	"Have not been controlled by traversing tackles, but have fetched way to leeward."
"Black Prince"	9,137	28	192	47	4	24	709	
"Hercules"	8,677	14	195	44	10	4	630	
"Lord Warden" and "Lord Clyde"	7,842	18	164	48	16	2	606	"In a sea-way they are faulty." "When there is only a slight rolling motion, it is difficult to keep the gun steady."
"Bellerophon"	7,551	13	145	48	10	3	545	"Scott's carriage and slide have been put to the severest tests, and in every trial have worked easily and well."
"Caledonia" and "Ocean"	6,832	24	166	41	4	20	615	
"Prince Consort"	6,832	15	160	43	15	...	605	"The present chains (Scott's running-in) are very efficient."
"Hector" and "Valiant"	6,713	18	122	55	2	16	600	"The compressors could not be depended upon, and the train whips carried away."
"Royal Alfred"	6,707	18	177	38	10	8	606	
"Swiftsure" and "Triumph"	6,633	14	139	44	10	4	450	
"Royal Oak"	6,366	24	166	38	4	20	606	
"Repulse"	6,190	12	108	57	12	...	—	
"Zealous"	6,096	20	130	49	...	20	511	
"Defence" and "Resistance"	6,070	16	109	55	2	14	460	
"Audacious" and "Invincible" "Iron Duke," and "Vanguard"	6,034	14	139	43	10	4	450	
"Penelope"	4,394	12	80	55	8	4	—	
"Hotspur"	4,010	3	32	125	1	2	190	
"Pallas"	3,787	8	50	76	4	4	252	"Unless great attention is paid to the traversing tackles, the gun is liable to fetch way, to the great danger of the gun's crew."
"Favorite"	3,232	10	59	55	...	10	271	
"Research"	1,741	4	26	67	...	4	150	The "indestructibility, power of control, training, elevating, and the smallness of its crew (9 instead of 19) is very manifest" in "Scott's carriage."
"Enterprise"	1,350	4	26	52	...	4	132	
"Waterwitch"	1,279	2	13	98	...	2	83	
"Viper" and "Vixen"	1,228	2	13	94	...	2	83	

whole offensive powers. Besides this superiority in mounting, the "Sultan" is the most powerfully-armed ship afloat. Carrying the same weight of artillery as the exceedingly well-armed "Hercules," and as the wretchedly-armed "Minotaur;" the "Sultan's" ordnance is concentrated into fewer pieces, viz., into eight 18-ton and four $12\frac{1}{2}$-ton guns; and all these guns have high slides and low carriages, which lessen the shock upon the deck, and can be fought without pivot bars, should the side be indented and the pivot bolts bent by hostile shot.

The "Swiftsure" and "Audacious" classes do not fully possess these advantages for their ten $12\frac{1}{2}$-ton guns, whilst each is disfigured by antiquated four-truck carriages for four $3\frac{1}{4}$-ton 64-pounders, which require more men to jerk them about inefficiently than are employed for the accurate and smooth working of the other four-times-heavier weapons.

Armaments of Unarmoured Ships.—In former times, for lack of concerted action between the artillerist and the architect, the Military Carriage Department and the Naval Constructors, the War Office and the Admiralty, the smaller classes of ships were first built, and then the armament was determined on. This led, in many flush-decked vessels, to strange contrivances for impeding the handling of ordnance.

Typical Unarmoured Ships.	Weight in tons.	Heavy Guns.			Gun Carriages.		Complement of men, &c.	Remarks.
		Number of pieces.	Total weight.	Tons weight of ship per ton of gun.	Worked by machinery.	Worked by ropes.		
	tons.	No.	tons.	tons.	No.	No.	No.	
"Inconstant" ..	5,782	16	164	35	10	6	605	
"Blonde" ..	5,696	26	155	37	2	24	600	Mechanical slides, 18 inches shorter than usual.
"Raleigh" ..	4,655	22	108	43	2	20	500	Do. Do.
"Ariadne" ..	4,583	26	97	42	—	26	540	Cannot fire a gun in a seaway.
"Volage" ..	3,078	8	46	67	—	8	300	
"Active" ..	3,078	10	52	59	—	10	300	Two common truck carriages.
"Scylla" ..	2,187	17	55	40	—	17	275	
"Blanche" ..	1,755	6	27	65	—	6	180	
"Dido" ..	1,755	8	33	53	—	8	180	
"Daphne" ..	1,574	4	20	78	—	4	180	A 64-pounder on truck carriage to be added.
"Cruiser" ..	1,045	5	20	52	—	5	177	
"Myrmidon" ..	877	2	10	87	—	2	101	
"Swallow" ..	774	3	10	77	—	3	100	
"Blazer" ..	254	1	18	14	1	—	—	Machinery for running in and out only.
"Banterer" ..	218	1	5	44	—	1	40	
"Staunch" ..	180	1	$12\frac{1}{2}$	14	1	—		Do. Do.

To a less extent this lack of concert is still observable in the mounting and working of artillery in certain of the smaller vessels. Not only is the weight of their guns out of all proportion to their tonnage, but they are squeezed into such confined spaces, that it is exceedingly difficult to use effectively even such weapons as they carry. A Captain, who was formerly a Gunnery Officer, and who was recently in command of such a vessel, writes that: "the fittings were of such an ante-" diluvian type that, unless you happen to be giving a lecture on fossil " armaments, I can hardly think that any allusion to her would be " acceptable."

There is only one unarmoured ship, the "Inconstant," with decent mountings for her guns, and even that vessel has not the best form of mechanical slides for her ten $12\frac{1}{2}$-ton guns, and has six inefficient rope-worked slides. The "Blonde" and "Raleigh" will each have two complete 9-inch gun-slides, but they are to carry respectively 24 and 20 inaccurate rope-worked slides. We have not a single other gun efficiently mounted in unarmoured ships.

Small-Craft Armaments.—Several officers recently in command of sloops of war have told me that they found it exceedingly difficult to get the full value out of their armaments (some of which are described as miserably ineffective), in consequence of the inefficient contrivances for mounting and working them. One of these officers writes, "Our forecastle was too small for the slide to travel right round, " and necessitated its being shifted to three different rear bolts, or, in " other words, the practical impossibility of moving the gun from one " broadside to the other in the heat of an action. Moreover the ham-" mock netting and bulwarks which had to be cleared away for action " consisted of upwards of 100 separate pieces. As to there being any " real facilities for working the guns there were none."

The "Dido" class are 1,755 tons weight, and mount two 7-inch $6\frac{1}{2}$-ton and six new 64-pounders of 64 cwt. This is one ton of artillery for every 53 tons weight of ship. The new 64-pounders are made six inches shorter than the converted ones specially to suit their narrow and encumbered decks. The pivot-bars of the 7-inch gun slides are also shortened in these vessels; and the guns are secured fore-and-aft amidships, side by side, between the mainmast and funnel casing.

The "Daphne" class are vessels of 1,574 tons weight, carrying two $6\frac{1}{2}$-ton on slides and two $3\frac{1}{2}$-ton guns on common truck carriages, or one ton of artillery for every 78 tons weight of ship. Their Officers state that those on truck carriages cannot keep pace with those on slides, and are consequently of small value. The slides are of the objectionable rope-worked pattern. By a very complicated and tedious arrangement both $6\frac{1}{2}$-ton guns can be fought on the same broadside; but are then very inconveniently close to one another, and give the ship a heel of 6°, adding in a sea-way to the difficulties of safe, smooth, and rapid working. It is even said that the insecurity and difficulties of this rope-worked 7-inch gun slide, when the sea is in lively motion, are such as to have suggested the idea, not of improving the mechanical appliances, but of turning down two tons off the weight of the $6\frac{1}{2}$-ton gun.

The lack of concerted action between the Military and the Naval Departments is very evident in the case of the new "Swallow" class. These are vessels of 774 tons carrying one 7-inch $6\frac{1}{2}$-ton, and two 40-pounders Armstrong breech-loaders, of 35 cwt., or one ton of artillery to every 77 tons weight of ship. The 40-pounders are not very useful weapons, and the real power of the armament centres in the 7-inch gun. When we remember that the "Stork" and other little 60 h.-p. gun-boats of about 250 tons carry a similar gun, and that the "Bustard," of 254 tons weight, carries a 10-inch 18-ton gun, the offensive powers of the "Swallow" will not appear very formidable. Yet, such is the lack of fore-and-aft space, that the 7-inch gun cannot be trained more than 30°, the slide then coming into contact with the main bitts. The bad expedient of shortening the pivot-bar cannot, in this case, be resorted to because of the wall-sidedness of the bulwarks. We have thus a weak armament, badly mounted, squeezed into a space so confined as to further limit its useful action. These various armaments are to be found amongst the most recent and most favourable specimens of our smaller vessels of war.

The 20-pounder Carriages.—A Captain recently promoted from a 5-gun vessel of 570 tons, writes:—"The armament consisted of one 64-pounder and four 20-pounders. The latter were mounted on low rear-chock carriages, so low that the captains of the guns had to lie down to see along the sights if the ship heeled over a few degrees towards the object." These little guns, which had been promoted from boat-service to the broadside of a ship-of-war, had no training gear, and were jumped about by hand-spikes when pointing, showing that the general rule obtains even with 13-cwt. guns that the smaller the gun, the worse the mounting.

The Four-truck Carriages.—Upper deck armaments often contain an admixture of 64-pounders of 71 cwt. This rifle is essentially a shell gun, and, though useless against the thinnest ironclad, may, if properly mounted, do good service against wooden ships and in bombardments. As it is, the 64-pounder has received an accession of 6 cwt. to its weight in the process of conversion from a 65-cwt. smooth-bore, and is still frequently mounted upon the primitive wooden truck, which is so well known for its jerky motions after the gun "woods," and for causing waste of brute force, and loss of time. Moreover, these rude carriages forbid correction being applied to the alteration of quadrature at different angles of training incidental to curved decks, which, by inclining the sights from the perpendicular, vitiates, beyond point blank range, both the elevation and the direction, and is absolutely fatal to accuracy.* It is highly discreditable to our artillery intelligence, that such primeval and inaccurate mountings should be applied to two rifled guns out of ten, in the "Active," (sister to the "Volage"); to two guns out of three in the "Hotspur;" and to the upper deck guns of our most recent ironclads.

The 64-pounder Gun-slides.—The "Volage" is an unarmoured ship

* See the Error of the Bow Gun, and other Errors incidental to the Practice of Great Guns at Sea, by Commander B. Sharpe, in Journal of the Royal United Service Institution, vol. vii, No. 26, 1863.

of 3,078 tons, carrying two 64-pounders, 71 cwt., on old-fashioned slides, and six 7-inch $6\frac{1}{2}$-ton guns on little less objectionable rope-worked slides. This ship carries, in all, 46 tons of artillery, or one ton of guns to every 67 tons weight of ship; whilst the "Royal Alfred" carries, in addition to her thick armour plating, one ton of artillery to every 38 tons weight of ship. Moreover, whilst most of the offensive powers of the "Royal Alfred" are developed by the use of accurately working mechanical gun carriages, those of the "Volage" are crippled by inefficient gun mounting, and the ship is absolutely inoffensive in a sea-way. The "Volage's," two 64-pounders on old-fashioned slides, with single ropes for running in, could not be used at all in a sea-way without great danger of crushing their crews, injuring the ship, or tumbling overboard. The cause of this will be evident when we remember that the power applied to run in a 64-pounder is multiplied but twice on the train whip, and not at all on the side tackles. Whereas, the machinery employed to run in and out a $12\frac{1}{2}$-ton gun multiplies the manual power applied to two handles 59 times; and by very simple alterations of the mechanism, the running in and out gear of the 18-ton gun multiplies the manual power 80 times, and that of the 25-ton gun does so 120 times. The compressors of these mechanical carriages are so arranged as to aid the running-in gear in controlling the gun when moving in or out. But, even in moderate weather, the 64-pounders on slides, call for the united efforts of many men to run them in with a slight heel, and, whilst on their rollers for that purpose, are not controlled by compressors or other gear, and are apt "to take charge" altogether if the ship gives an unexpected roll. Their racers are not levelled up at either end to correct the influence of deck curvature on the sights when the gun is extreme trained; and the rough action of tackles is highly prejudicial to promptitude and nicety in imparting delicate touches to the aim. They are, therefore, the fruitful cause of much bad shooting in all weathers, of large unnecessary expenditure of ill-applied brute force, and of danger in a sea-way. These slides being as long as the new ones for the $12\frac{1}{2}$-ton guns, narrow ships have these guns squeezed in anyhow and anywhere; whilst the new 64-pounders are made six inches shorter than the converted ones to get them into ships with small beam, and midship impediments. Surely the mechanical skill which can squeeze a 25-ton broadside gun into a space within six inches of its own length, and work it safely in all weathers with four men, could contrive that a $3\frac{1}{2}$-ton gun might be mechanically worked, with as much accuracy, by as few men, and in similar weather, on slides of proportionate length.

The 7-inch Gun Slides.—7-inch $6\frac{1}{2}$-ton guns are mounted on rope-worked slides, which are raised on eccentric rollers for training by tackles, the elevation on and off the eccentrics necessarily disagreeing, and the alignment of the sights being liable to disturbance by the slide falling unevenly off its rollers. The running in and out gear is also of rope, worked by winches. The pivot bar bears the full force of the recoil unassisted by the racers, and an enemy's shot bulging in the ship's side, might jam the pivot and render the gun useless. The racers are not levelled for correction of deck curvature. Delicacy of

touch in aiming is precluded by these clumsy contrivances; whilst safety in a sea-way is equally sacrificed. For lack of concerted action, the Military Carriage and the Naval Constructive Departments, contrive to make matters worse. The total length of slide is 12 feet, being within six inches of the length of those for the $12\frac{1}{2}$-ton guns. Thus occupying more space than mechanical ones, they can only be squeezed into narrow ships like the "Volage" by shortening their pivot bars. But the coned rollers beneath the fore end are bevelled for 5 feet 1 inch radius, and they naturally refuse to revolve when this radius is thus trified with. Even after this mutilation, the hatchways, skylights, and other midship impediments are found to impede the action of the rope winches. In the "Volage" class, the 7-inch guns, are, when not in use, secured fore and aft, in the middle of the deck, and right in the way of the principal working ropes. To get the guns into action from this position in a sea-way is a matter of some difficulty and danger; and, even in a moderate breeze, it has taken 20 minutes to get the weather guns on to their pivot bars. This delay in fine weather might have been avoided had the ship been designed to carry the guns on the fighting bolt, trained to an angle of about 20° or 30° with the fore and aft line.

Even when used for the bow and stern guns of such remarkably steady ships as the iron-clads "Hercules" and "Monarch," the rope-worked 7-inch gun slides were reported by their Captains to be inefficient. Whilst from more lively ships the official reports of their performances in a sea-way are most alarming, contrasting strangely with the safe and easy movements of guns two, three, and four times as heavy, worked by machinery. Thus, after a day's shooting in a gale, the late Admiral Warden reported that "two of the guns at different times got the better "of the crew, and banged in and out of the ports several times with "extreme violence, and two of the slides were to a certain extent "damaged by it. . . . . The result of that day's experience "would seem to prove that it is possible (though certainly never de-"sirable) to cast loose and fire these 7-tons guns in a sea-way, either "singly or a few at a time, with well-trained men or experienced crews; "but under the circumstances of that afternoon, I add, that it would "have been utterly impossible to have gone to general quarters or "fought an enemy's ship."

Captain Roderick Dew, C.B., of the "Lord Clyde" reported:— "the rolls cause the guns to take charge, when the whole strain comes "on the fighting bolt or flap, resulting, as on one occasion, in the dis-"abling of the slide."

Captain Connolly, of the "Pallas," reported, when working the 7-inch guns in a fore and aft position, "with much rolling motion, "unless great attention is paid to the traversing tackles, the gun is liable "to fetch way, to the great danger of the gun's crew between the gun "and the ship's side."

Captain Luard, of the "Hector," reported that "the compressors "could not be depended upon to control the guns, and the train whips "carried away."

Captain Vansittart, C.B., reported that "the heavy guns ($6\frac{1}{2}$ tons)

" cannot be worked satisfactorily. . . . . For those capable of a " fore and aft or bow and quarter line of fire, mechanical training gear " is absolutely necessary."

Captain Boys, of the "Excellent," reported of the "Warrior's" $6\frac{1}{2}$-ton guns that he "found on more than one occasion with ship rolling, " that guns trained before or abaft the beam have not been controlled " by traversing tackle with rollers eased up, but have fetched way to " leeward until they have been brought up by the ship's side."

Captain Goodenough, of the "Minotaur," reported that "tackles " are insufficient altogether."

Thus we have abundant official testimony that rope-worked gun-slides even for $3\frac{1}{2}$- and $6\frac{1}{2}$-ton guns are dangerous in every way; and that the ship so provided is utterly useless for purposes of war in a gale. Whilst, on the other hand, we have the clearest testimony from Captain Goodenough, Lord Gilford, and many others, that gun-slides can be worked by machinery with perfect safety in any weather. The Lords of the Admiralty themselves testified in a Board Minute, in 1869, that "in the 'Hercules' the 10-inch M. L. R. guns are worked with extra- " ordinary facility by the admirable machinery of Captain Scott, whose " improvements in gun carriages and their gear have been extensively " adopted in the Navy."

Rear-Admiral A. Cooper Key, C.B., F.R.S., when Director-General of Naval Ordnance, thus recorded his opinion of the comparative merits of machinery and of rope in working guns at sea:—"Owing to the " great improvement in gun-carriages, the 9-inch gun of $12\frac{1}{2}$ tons has " a great advantage, in case of handling, over the 68-pounder of $4\frac{3}{4}$ tons, " being worked with few men, greater rapidity, *and far more security*."

The present Director-General of Naval Ordnance was one of six Officers who, in 1867, tested the carriages of the 12-ton guns of the " Royal Alfred " and " Bellerophon," and recommended the application of Scott's training gear, as "the one thing wanted is a thoroughly " efficient mode of training." They reported that, even in its then inefficient state, "with the present mechanical arrangements for working the " 12-ton gun, we have no hesitation in saying that it is, in every " respect, worked as easily, if not more so, than the $6\frac{1}{2}$-ton gun." Since that date, Captain Scott's plans have been adopted in their entirety in the " Sultan," &c., with vastly enhanced efficiency; but the old rope-worked carriages continue to militate against the full use of the $6\frac{1}{2}$-ton and smaller guns.

Why on earth, then, that which answers so well with 18-ton guns should not be applied in a modified form to $6\frac{1}{2}$-ton guns, passes my understanding.

Mechanical Slides.—All guns of 9-tons weight and upwards are mounted on iron carriages and slides worked by mechanical appliances. Though the 8-inch and 9-inch gun slides are furnished with rollers and heavy racers, the main result of the recoil is received on a pivot-bolt in the port close behind the armour plating. A blow from a hostile shot bulging in that plate might easily jam the pivot bar and put a stop to all training. Years ago it was proposed to render the gun independent of distortions of the ship's side, by doing away with pivot

bars and receiving the recoil on the racers as is now done in the 25-ton broadside gun. Years ago the high slide and low carriage was urged as a means of lessening the force of the recoil upon the slide and thence upon the deck. Had those and other suggestions been attended to at first, instead of at last, we should not now have so many incomplete carriages on hand. Those of the older pattern for 8-inch and 9-inch guns have several departmental piracies and so-called "improvements" of the original designs. These having failed to stand the test of prolonged experience at sea, are no longer being constructed, and the more recent ironclads have been provided with more perfect 9-inch carriages and slides. The 18-ton, 25-ton, and 35-ton guns appear to have been beyond the powers of "improvers," and their mountings have from the first been constructed on true principles, certain details being altered by the inventor as new and more simple mechanical powers, especially in the application of hydraulics, were devised. This, perhaps, explains why neither of the gunnery ships is provided with a single example of a complete mechanical gun-carriage and slide, or a model or picture or printed description of one. They have, for example, no means of giving instruction in working the brakes which are used to control guns of 9 tons weight and upwards in sea-going vessels. Heavy gun firing is conducted in their gunboats, from 9-inch gun slides having no training gear, but so fixed that the lateral direction is given by movements of the helm; and from 7-inch gun slides trained by tackles. Neither brakes, which hold the training gear when in motion at sea, nor traversing gear for moving the gun from port to port have been fitted in the "Excellent" herself; whilst the pauls for holding the gun when it is stationary are of an obsolete pattern, and seem to be used as if they were brakes. When accidents occur in sea-going ships from ignorance of mechanical apparatus, we must not blame those officers and seamen gunners who, having never previously seen or heard of them, remove, or grease, or otherwise render useless the controlling brakes. Still less should we blame machinery dealt with in such fashion by untrained men. The chapter on "Heavy Rifled Gun Exercise," in the "Manual of Gunnery for Her Majesty's Fleet," is based on the notion that 9-ton and $12\frac{1}{2}$-ton guns are trained by tackles, the fact being that the cord which forms the trigger line is the nearest semblance of a rope which is, or at least ought to be, about them. What between the rare collection of obsolete and make-shift appliances in the "Excellent," and an imaginative handbook of gunnery, enquiries as to apparatus actually in use at sea are pursued under some difficulties. These sources of information as to the transition stage being within the reach of most naval men, I will confine myself to descriptions of the less "improved" upon, and therefore more perfect apparatus now being constructed.

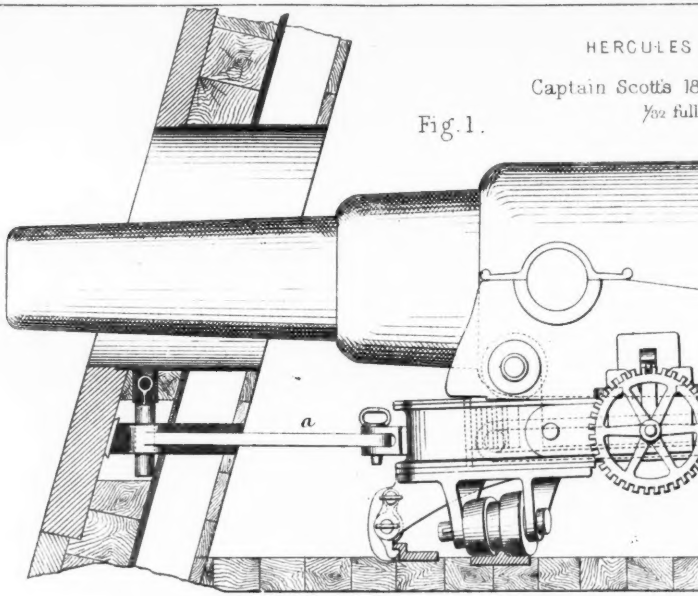
More Complete Mechanical Gun Slides.—Much intelligent experience has been gained by Captain Lord Gilford, Gunnery Lieutenant Ingles, and the Officers and men of the "Hercules," of eight 18-ton broadside guns, fitted with the more complete apparatus. Lord Gilford wrote three years ago that, during a moderate gale, "the men worked the "guns with the same ease and confidence as if the ship was in dry "dock;" and again, six months later, after a heavy gale, "I believe

HERCULES

Captain Scott's 18

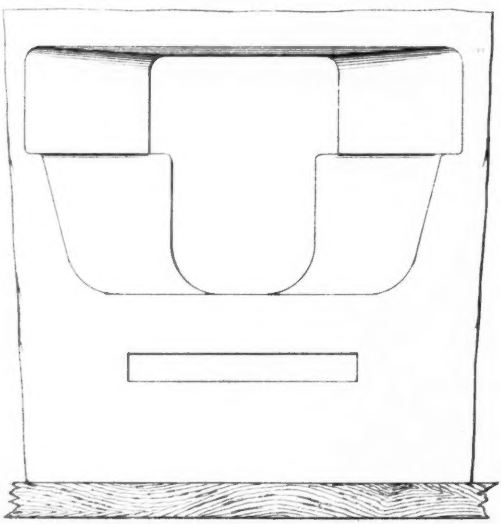
1/32 full s

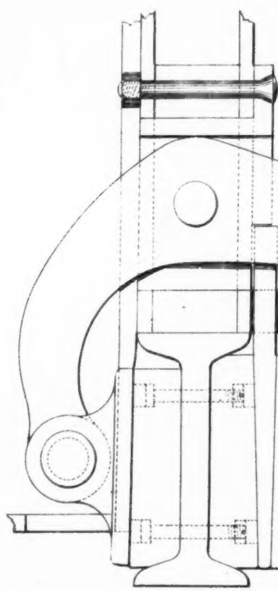
Fig. 1.



Elevation of Port (Sultan)
1/32 full size

Fig. 4.

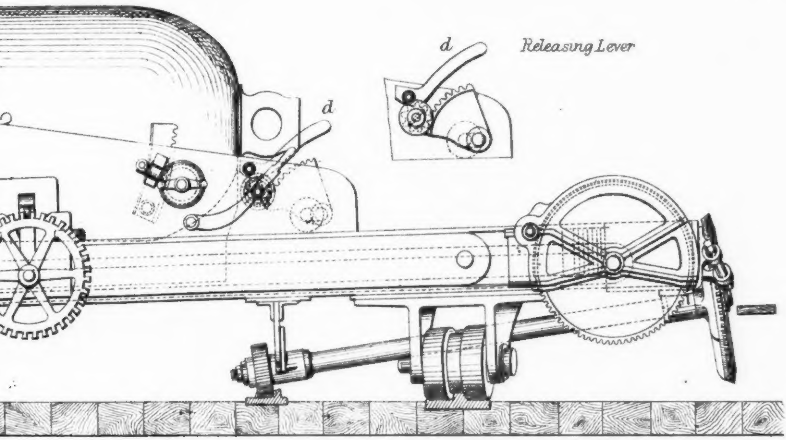




RCULES AND SULTAN.

Scott's 18 Ton Gun Carriage.

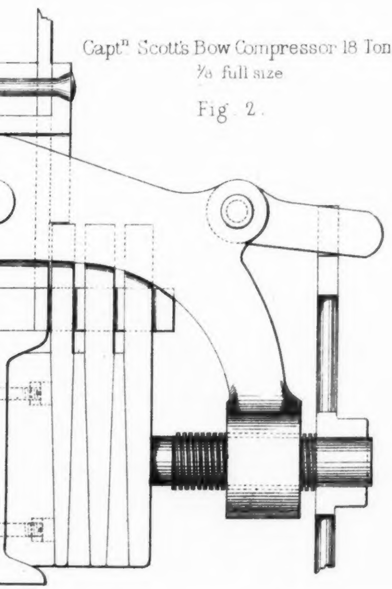
$\frac{1}{32}$ full size



Capt^{n} Scott's Bow Compressor 18 Ton Gun

$\frac{1}{8}$ full size

Fig. 2.



Side view

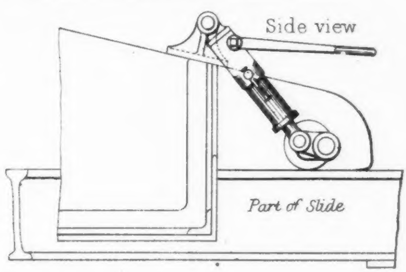
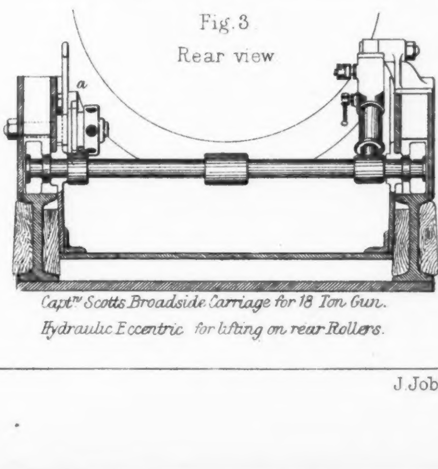


Fig. 3

Rear view



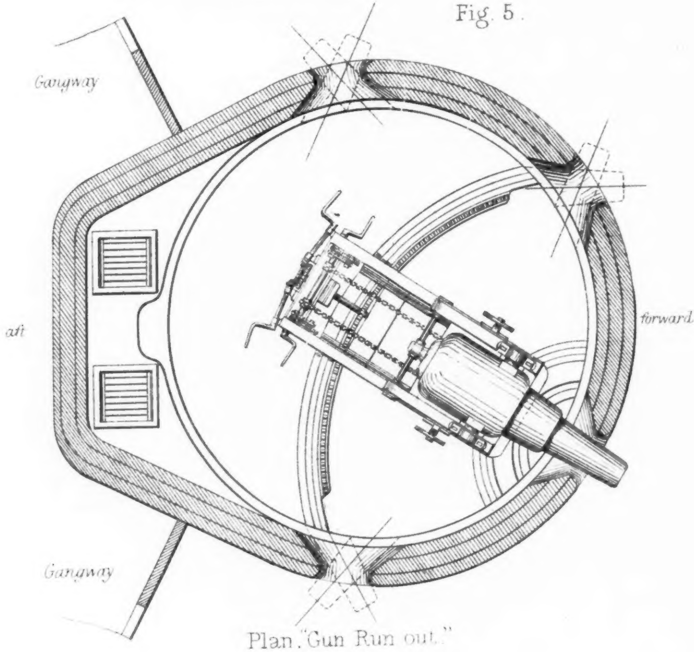
Capt^{n} Scott's Broadside Carriage for 18 Ton Gun.

Hydraulic Eccentric for lifting on rear Rollers.

J. Jobbins

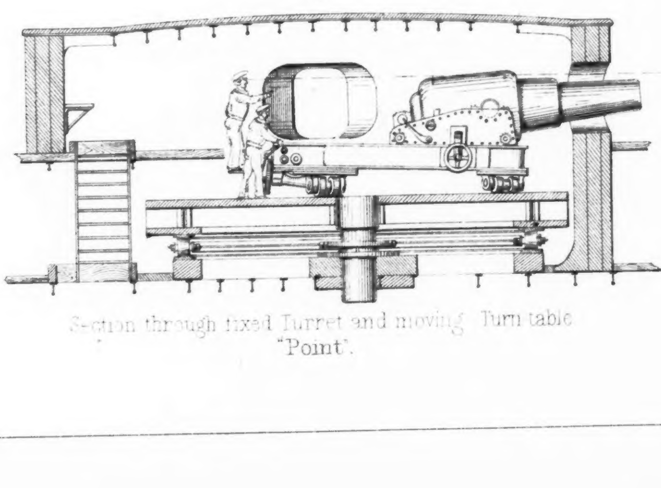
CAPTAIN SCOTT'S BROADSIDE 25 TON GUN CARRIAGE IN "HOTSPUR'S" FIXED TURRET

Fig. 5.



Plan. "Gun Run out."

Fig. 6.

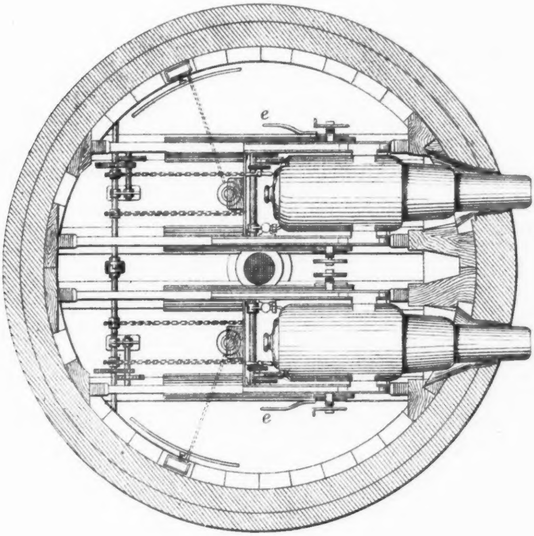


Section through fixed Turret and moving Turn table
"Point".

s"

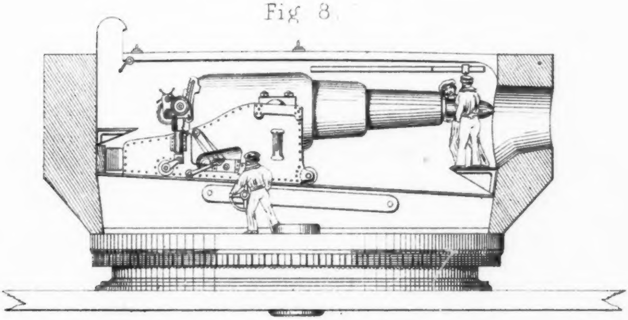
CAPTAIN SCOTT'S TURRET CARRIAGES & MACHINERY FOR WORKING
THE 35 TON GUNS IN H.M.S^{s} "DEVASTATION" & "THUNDERER."

Fig. 7



Plan. "Guns Run out."

Fig. 8.



Section. "Load"

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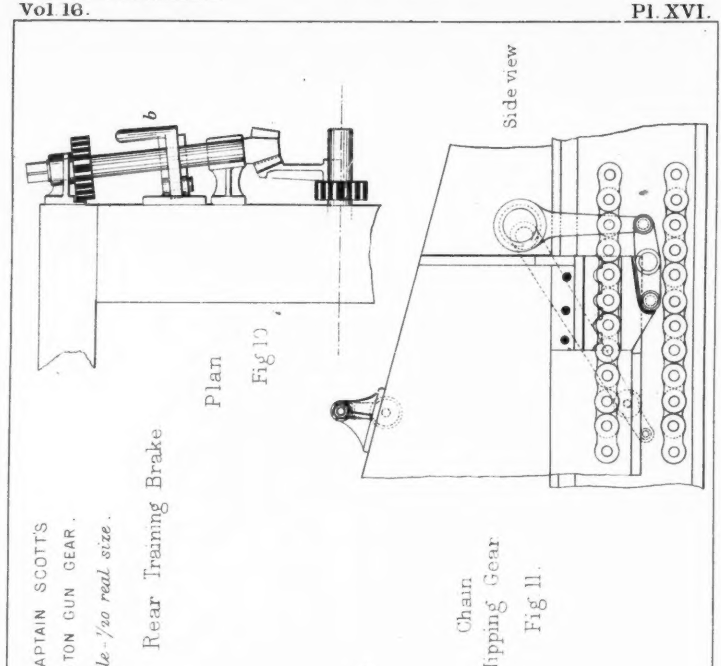

CAPTAIN SCOTT'S
25 TON GUN GEAR.
Scale - 1/20 real size.
Rear Training Brake
Plan
Fig 10
Side view
b
Elevation Fig. 9
c
End view.
Chain
Nipping Gear
Fig 11.

J. Jobbins

"the battery guns could have been worked, and the ship taken into "action at any time during the gale, using steam with full power." The "Sultan" is also fitted with eight 18-ton broadside guns, so mounted.

The leading principles observable in the complete mechanical carriages are great constructive strength; powerful moving machinery, so contrived as to be unaffected by the concussion of firing; self-acting controlling gear, almost independent of human carelessness; the gradual absorption of, rather than rigid resistance to, shocks; the dispersion of concussions over large surfaces; independence of distortion of or other injuries to the ship's side; smoothness and ease of motion in every direction, and safety under all conditions of the sea.

The most obvious specialities of these perfected mountings are:—

1st. (Plate XIV, fig. 1.)—Long, low, mixed cast and wrought iron carriages, on short, high, girder iron slides. The low carriage remedies the rearing back tendency of short high ones, and the consequent downward strain on the slide and deck. The height of the 10-inch gun slides at the centre of the trunnions is 2 ft. 2 in., and that of the carriage 1 ft. 11 in., making 4 ft. 1 in. in all, on board the "Hercules." The ports of the "Sultan" require the roller lugs of the 10-inch gun slides to be 3½ inches higher. The heights of 9-inch carriages and slides are similarly proportioned. The complete 9-inch gun slides, are found only in the "Sultan," "Blonde," and "Raleigh." They have no head-plate in front, and being thus made 18 inches shorter, they allow the gun to run further out, and occupy 18 inches less space. The pointing is also improved, and the length for recoil remains as before. Whilst maintaining the same height of trunnion above the deck when run out (viz., 3 feet 8 inches), the new carriage is 1 foot 8 inches high, or 11½ inches lower than the older pattern, the slide being raised to the like extent. The small space occupied by these short mountings diminishes the extent of armoured cover, and this again reduces the tonnage of the ship, and enables a handier vessel of lighter draft to carry protected guns of equal weight. Thus, the total length of the new slides, for 12½-ton guns, is 12 ft. 6 in., and of those for 18-ton guns is 15 feet; the total length of their carriages being respectively 6 feet, and 8 ft. 7 in., affording a recoil of 6 feet.

(Plate XV, fig. 5.)—The 25-ton broadside gun of the "Hotspur" is mounted on a slide only 15 ft. 6 in. long by 6 ft. wide, the carriage being 8 ft. 9 in. long. The axis of the gun is 5 ft. 1½ in. from the deck, the top of the carriage being 2 ft. 3 in., and the top of the slide 2 ft. 10½ in. in height. Being so near the water, the ports only provide for 2½° depression on the beam, and 1° right ahead, with 11° elevation. Each beam port gives an arc of 68° training, 44½° aft being abaft the beam. Each bow port gives training from 1° inside the line of keel to within 22° of the beam, thus overlapping the arc of the beam port. The turn-table is used to change the gun from port to port; the training gear for moving it laterally when there. There is an arc of 91° round the stern, undefended, except by a couple of 64-pounders mounted on wretched four-truck carriages, which require between them seven times

the number of men that it takes to train the 25-ton gun under the same conditions of sea.

2nd. (Plate XIV, fig. 1.)—The slides rest permanently upon their four coned-and-grooved rollers, on heavy solid metal racers, which brace and strengthen the beams and decks beneath, and are raised at the ends, so that the sights may not be affected by the curve of the decks.

3rd. (Fig. 1.)—The recoil is received from the grooved rollers by metal ribs cast on the upper face of the deck racers, and from a strong metal hook which ties the fore part of the slide down to the strong projecting lip of the front racer. There is also a single pivot bar (*a*), with movable pivot bolts in the slide and in the port behind the armour plating; but this is not essential to security, and the bar can be disconnected from the slide or from the port if necessary. The pivot bar is, indeed, omitted from the slide of the 25-ton broadside gun mounted on the "Hotspur's" turn-table, Fig. 6, pl. II, and though less in the way of loading than the V-shaped pivot bar, it might be dispensed with in lighter guns advantageously.

4th. (Plate XIV, fig. 2.)—The self-acting bow compressors consist of strong iron bows hung by their centres through a hole in each side bracket. From the carriage, short wedge-shaped plates are suspended between hard wooden baulks and wedge-shaped iron bars fixed to the girders of the slide. The weight of the gun when let down off its carriage-rollers drives the upper wedges tight between the lower ones, and the downward concussion of firing tends to press them still further home; whilst the action of lifting the carriage on its rollers, to run the gun in or out, relieves the wedges. A screw at the outer end of each bow, turned by a wheel, Fig. 1, sets each compressor hand-taught. The circumference of each wheel is provided with notches which are held by a paul. In practice, the pauls of both compressors may be permanently set to a given notch, or that on one side may be so fixed, and the other used to control the gun in running in or out. Firing battering charges of "brutal" R.L.G. powder and shell from the "Hotspur's" 25-ton broadside gun at sea, Fig. 6, pl. II, one man to each compressor, hove them so taught, that the recoil did not exceed three feet, and it became necessary to slacken the wheels five notches of the paul, to allow sufficient recoil for reloading. Once rightly adjusted, neither compressor was touched when moving the gun in or out.

5th. (Plates XIV, and XVI.)—Fig. 1. The mechanical training-gear consists of a crown wheel and bevel pinions driven by winch handles, which turn a shaft beneath the slide, armed with a cog-wheel working into a cog racer in the deck. A second driving pinion is provided, Fig. 9, giving twice-and-a-half more power, for use when the gun is so extreme trained that only one winch-handle can be worked, or in rolling, or at any time when extra mechanical power is needed. A paul, Fig. 10, *b*, is provided to be kept down when the gun is stationary, and a controlling brake, Fig. 9, *c*, for use when the gun is in motion. The brake consists of a diminutive bow compressor applied to the training gear near the winch handle. The object being to prevent the cog-wheel and shaft revolving, it is evident that brake power applied near the

winch-handle gains all the advantage of the power given by the multiplying gear, in addition to its own frictional surfaces.

The power gained in training $6\frac{1}{2}$-ton guns by the usual tackles is, at most, only three times the manual effort applied. Moreover, the loss of time in taughtening the tackle, and before the force of several men can be united in one combined pull; and the loss of space by stretching of the rope, makes it an exceedingly rough and unready mode of attempting to impart refined motions to heavy artillery. Whereas the manual power applied on two handles to mechanical training gear is multiplied 37 times in the case of $12\frac{1}{2}$-ton guns, 52 times in the 18-ton guns, and 90 times in the 25-ton guns. Whenever greater training force is needed, the handles can be readily attached to the additional pinion Fig. 9, which multiplies these mechanical powers two-and-a-half times. Thus, the force exerted by one man on each handle in training a $12\frac{1}{2}$-ton gun, becomes, by the use of machinery, equivalent to that of 92 men relying exclusively on brute force; and to that of 130 men in training an 18-ton gun; whilst two men do the work of 225 men in the case of the 25-ton gun. Moreover, the machinery can be applied with great promptitude and exactitude, contributing greatly to the rapidity of pointing at moving objects, or with quick helm movements.

6th. Where a turn-table is not employed under the rear of the slide to turn a foremost or after gun from a broadside to a bow or stern-port, and *vice versâ*, traversing apparatus is added to the training gear, Fig. 1. For this purpose, the training shaft is prolonged, and an additional cog-wheel works in a cog racer under the fore end of the slide, suitable means being provided for throwing the training gear out and the traversing gear into gear, and *vice versâ*, when needed.

Traversing turn-tables are fitted to transport fore or aftermost broadside guns to and from the bow or stern-ports, to 18-ton guns in the "Hercules" and "Sultan," and to $12\frac{1}{2}$-ton guns in the "Sultan," "Lord Clyde," "Lord Warden," "Blonde," and "Raleigh."

7th. (Plates XV and XVI.)—For the longitudinal motion of the carriage upon the slide, running in-and-out gear is fitted. This consists of spur wheels and pinions worked by winch handles, which drive a shaft placed across the rear part of the slide, Fig. 5. Two endless chains run round sprocket-wheels on this shaft and on the fore part of the slide. When out of action the chains are not attached to the carriage, but, when needed, nipping eccentrics in the carriage, Fig. 11, being worked by a lever, catch the chains in their teeth.

8th. (Plate XIV, figs. 1—3.)—For running in or out, the carriage is lifted upon rollers by means of rear eccentrics, which are worked by an hydraulic on one side; or by notched arcs, near the other bracket, acted upon by pointed handspikes temporarily placed in sockets either in the eccentric shaft or in a drum attached to it. Pauls are provided for holding the eccentrics when the carriage is on the rollers. Buffer blocks are fitted to the fore part of the slide to receive the carriage in running out, in case, through inattention, it is carelessly permitted to strike heavily against the slide, and thus dislodge the projectile and charge from their seat. This carelessness should, however, be averted by a careful explanation to the crew of the evil consequences resulting from it.

9th. (Plate XIV, fig. 1.)—Complaints are occasionally made against the elevating gear which was adopted instead of Captain Scott's, but, on the whole, it seems to answer very fairly. It consists of a notched arc attached to the gun, acted upon by a cogged wheel and drum connected with the carriage. The periphery of the drum is pierced with sockets, into which pointed handspikes are temporarily placed, a clamp nipping the drum when the desired elevation is attained. A holding pin to take the sockets has been recently added to help the nipping clamp.

Royal Carriage Department.—It is due to the Director-General of Artillery and to the Royal Carriage Department to say that the workmanship displayed in these mechanical gun-carriages is of the highest order, and reflects great credit upon the manufacturing skill of the Royal Arsenal. This is so, not only in that which calls for most careful and skilful manufacture, but, so far as they afford opportunities for it, in the more primitive mountings, which stand condemned. The Navy does not and cannot find fault with the workmanship of any of its gunnery tools. It is exclusively to the form and design of some of them that we trace their failure to comply with the demands of naval warfare. When a mechanician, who is also a sailor and a gunner, supplies proper designs, the Royal Carriage Department possesses all the manufacturing skill requisite to embody those designs in most efficient forms. Let seamen gunners and mechanics agree upon such modifications of the heavier gun mountings as are needful to ensure accuracy of fire and safety of movement for the lighter guns, and the Royal Carriage Department is as fully competent to construct carriages for these latter guns, as they have shown themselves able to do so for 18-, 25-, and 35-ton guns.

Non-traversing Carriages.—The 9-inch guns of the 180-ton, "Staunch" class of gun-boats, and the 10-inch gun of the 254-ton, "Bustard" class, are mounted on slides similar to those already described, Fig. 1, excepting that they have no rollers and no training or traversing gear. They stand at the bows in line with the keel upon their two iron girders or chocks, a pivot bolt passing through each. In this fixed position, with the muzzle forwards, the object is brought on with the sights by the helm, thus involving alterations in the course of the vessel, and necessitating a constant advance in a direct line with the enemy. On occasions, the slide might be dragged round by main force to any fixed angle not exceeding 20° from the line of keel. What such vessels would do in narrow waters, or in a strong tideway, or in any case when the enemy was not standing still or running away, it is difficult to understand. There seems to be no adequate reason for withholding training gear, or for so limiting the angle of training. Every practical naval artillerist is aware that the compound motion imparted by combined rolling and pitching calls for promptitude and nicety of touch in training which the helm cannot possibly give; and that to attain equal accuracy from fixed guns, there must be very long and patient watching for chance shots, involving great loss of time. This wilful crippling of the power of the guns passes ordinary comprehension.

The 20-pr. Depression Carriages.—Though, in my opinion, the best

way to encounter a torpedo vessel is with her own weapon, a very useful auxiliary defence is provided in 20-pr. breech-loaders, mounted, upon special depression carriages, which give a plunging fire from the upper decks. The surface of the iron slide is sloped to the front to an angle of 10°, and it is furnished with an hydraulic compressor. The carriage is of iron, and an elevating arc affixed to the gun, and worked with a pinion and wheel, instead of the drum and handspikes used with heavy guns, admits of 20° elevation and 30° depression. But the shortness of the gun, and the thickness of the ship's side, reduce the depression to 25° in vessels of the "Vanguard" class. Thus, with the ship on an even keel, projectiles can be thrown 100 feet high at 100 yards distance, or into a boat as near as 13 yards from the ship's side. For some unaccountable cause these slides have no mechanical training gear, so that they cannot follow the object laterally with ease or rapidity.

Capabilities of Ports. (Plate XIV, fig. 4.)—The importance which attaches to plunging fire, when the ram fails to take effect, is obvious, and it is satisfactory to find that in recent broadside ships it has not been lost sight of. Thus the "Vanguard" class can depress the upper battery guns 8°, and, when on an even keel, strike the water 43 yards off, whilst the main-deck battery guns can be depressed $6\frac{1}{2}$°, hitting the water 37 yards off. The elevation varies from $9\frac{1}{2}$° to $10\frac{1}{2}$°, and the arcs of training of beam-ports are about 66°. Objection has been made to reducing the dimensions of ports, that it limits the field of view, and may give rise, in a general action, to guns being accidentally aimed at friendly vessels. On the other hand, large ports weaken the side, and expose both guns and gunners to hostile fire. To meet these difficulties, the "Sultan's" ports have been designed with their lower portions exactly corresponding to the space filled by the lower half of the guns in extreme training, and the upper portions enlarged laterally to give full arcs of view. Their width is 2 ft. 11 in. in the sight area above, and 2 ft. 8 in. in the lower portion, giving 70° of training, 10° of elevation, and 5° of depression. The main-deck portcills are 11 ft. 1 in., and the trunnions 12 ft. 7 in., above the water-line.. To still further limit the incursions of the sea and of hostile shot, various plans of muzzle-pivoting have been proposed, but the plan which has found most favour is the compound pivoting system adopted for turret ships. No steps have, however, yet been officially taken for applying the compound pivoting system to broadside ships.

Turret v. *Broadside Guns.*—Whereas in many of the smaller classes of broadside ships the artillerist has just cause of complaint that the one object for which ships of war are intended is too often forgotten in their construction or equipment; in H.M.'s turret vessels every other consideration is sacrificed to what few guns are carried. The chief advantage which the turret gives to the artillerist is a large training arc to a few heavy guns. On the other hand, when aiming considerably before or abaft the beam, the intervention of the deck seriously diminishes the capability of delivering a plunging fire even when on an even keel, whilst it precludes it altogether with a degree or two of heel. This loss of depression cancels a portion of the advantage gained by the larger arc of training. Thus, whilst the

"Monarch's" after-turret gives an average arc of training of 173°, including dead points obstructed by rigging, &c., the "Hercules'" broadside guns give only about 66° without changing ports. But if the ship heeled from $\frac{1}{2}$° to 2° from the object, the "Monarch's" guns could not, on extreme bearings, be laid horizontal, and would therefore be useless, and, even when the ship is upright, the after-turret guns could not, when trained aft, strike the water at a less distance than 550 yards. Whereas, at all points of bearing, the "Hercules" could depress the guns if the ship heeled 7° from the object, and, on an even keel, could strike the water so near as 40 yards.

Position of "Monarch's" turret guns.	Angle of Training.	Angle of depression deck admits of on even keel.	Nearest point of water struck on even keel.
			Yards
After turret, trained abeam.......	0°	7°	40
" " " aft..........	95°	$\frac{1}{2}$°	550
" " " forward......	78°	2	110
Fore turret, trained abeam........	0°	7°	40
" " " aft...........	74°	2°	110
" " " forward.......	78°	$1\frac{1}{2}$°	180

Again, our ablest artillerists hold that there is no sufficient cause why armour-clad broadside ships should not also carry additional unprotected guns quite as well as unarmoured vessels. Their offensive powers might thus be enhanced in bombardments, in distant firing, and in many of the lesser operations of naval war; whilst in pitched battles, with other ironclads, the crews could, if necessary, be temporarily withdrawn under cover from the unprotected guns, and the ships be no worse off than if they did not possess such additional weapons. Now, as to the whole line of the broadside this is quite impossible in one of HM.'s turret vessels, though she may carry a few auxiliary guns for end-on fire at the extremities. Moreover, the turret, as usually applied, curtails many of the purposes to which ships of war may be applied, as wholesome continuous abodes for large numbers of men, and for carrying troops in emergency, as well as impeding their convenient handling. Great as is the advantage of this increased arc of training to the artillerist, yet, viewing the ship simply as a mere multiple gun-carriage, it is questionable whether a "Devastation," with eight covered broadside 35-ton guns, and a number of lighter unprotected ones, would not compete successfully with the "Devastation," as she is to be, limited to two double turrets.

Of the turret ships, the armament of the coast defence vessels of the "Cyclops" class bears the heaviest proportion to the tonnage, and that of the "Rupert" bears the smallest ratio. The "Fury" will be the largest turret ship afloat. She will weigh 10,464 tons, or only 120 tons less than the broadside ironclad "Northumberland." Her armament will consist of four 35-ton guns, giving a total of 140 tons of

artillery. This is not much more than half that of the 28 guns of "Northumberland." Setting aside the question of longevity of heavy guns as effected by the "Woolwich" rifling, the "Fury's" armament would be unquestionably more formidable against a sister ship than that of the "Northumberland," or indeed than that of any other vessel afloat. But, as 35-ton guns can be quite as efficiently worked on the broadside, it is open to question whether a broadside ship of similar tonnage might not be so armed as to be equally effective against the "Fury," and far more effective for most of the numerous contingencies of naval war. The turret is, however, an existing method of mounting guns at sea, deserving our close attention.

Turret Ironclads.	Weight in tons.	Heavy Guns.			Gun Carriages.		Complement of men, &c.	Remarks.
		Number of pieces.	Total we	Tons weight of ship per ton of gun.	Worked by machinery.	Worked by ropes.		
	tons.	No.	tons.	tons.	No.	No.	No.	
"Fury"	10,464	4	140	75	4	—	300	Scott's compound pivoting carriages.
"Devastation" and "Thunderer"	9,188	4	140	65	4	—	250	Do. Do.
"Monarch"	8,322	7	131	63	6	1	525	Do. Do.
"Rupert"	5,284	4	43	123	2	2	200	Do. Do.
"Royal Sovereign"	5,080	5	62	82	5	—	—	Lifting slides.
"Glatton"	4,840	2	50	97	2	—	200	Scott's compound pivoting carriages.
"Prince Albert" .	3,905	4	50	78	4	—	—	Lifting slides.
"Cyclops," "Gorgon," "Hecate," and "Hydra" ..	3,336	4	72	46	4	—	150	Scott's compound pivoting carriages.
"Scorpion" and "Wivern"	2,751	4	50	55	4	—	155	Lifting slides.

Turret-gun-carriages. (Plate XV.)—The "Glatton" is the latest addition to our 25-ton gun turret ships, and contains some improvements in gun-mounting, partly suggested by the experience of hydraulics gained in the "Monarch." The substitution of hydraulics for levers has been delayed by the necessity of gaining experience as to those in use at sea. A quick working double action hydraulic jack, Fig. 3, has now been devised by Messrs. Tangye for universal application in lieu of levers, which is now being substituted to lift 18-, 25-, and 35-ton gun carriages upon their eccentric rollers for running in or out. These carriages can now be easily raised on their rollers by one man. The "Glatton" is 4840 tons weight, and mounts two 25-ton guns in one turret, or one ton of artillery to every 97 tons weight of ship. Four girder beams are built into the turret below the deck, Fig. 8, constituting strengthening struts, and forming a part of the ship, which might with advantage be decked.

These fixed girders form slides on which are placed two compound

pivoting gun-carriages, the training being effected by revolutions of the turret itself. The only point of principle in which the turret carriages differ from the broadside ones, is in their possessing compound vertical pivoting gear, to minimize the open area of the port. The aim is effected by sights on the top of the turret on which allowance is made for the difference of height above the gun. Inaccuracies in the parallelism of the sights and axis, are so far compensated by the greater distance between the front and rear turret sight, that, with rolling motion, better shooting is sometimes made than with the short radius sights on the gun itself. As already stated, the small port aperture was originally met by lifting bodily the gun-carriage and slide, to set heights or steps by means of four vertical screws acting irregularly beneath, an operation taking about an hour in smooth water, and scarcely possible in a sea-way. It is now met by raising the gun only. This is effected by supporting the gun on wrought iron trunnion blocks, susceptible of vertical motion in the carriage brackets. These blocks are united by a curved transom, acted upon beneath its centre by the ram of an hydraulic jack, Fig. 7, *e*, attached to the carriage, which raises the gun bodily about six inches per minute. Iron props of different lengths are used to support the trunnion blocks in the different positions in which it is intended to fire. On each step elevation or depression is regulated, as usual, by elevating gear, Fig. 8, which must necessarily differ from that attached to broadside guns, in that it has to be adapted for use with the axis at the three different heights. A single man moving a small wheel at the cascable of the gun, works the pinion and spur-wheel, which raise and lower the breech along the notched elevating bar. In the "Monarch" the steps are so arranged that the upper one gives no elevation, but 7° degrees depression; the bottom one no depression, but 15° elevation; and the middle step, which would be the ordinary fighting one, gives 9° elevation and 2° depression. This division of steps could be altered at any time by substituting iron props of other heights.

The carriages are adapted to the circular shape of the turret, by lengthening the inner bracket of each, and both carriages are so reduced in front of the trunnions as to leave a considerable interval between them and the turret walls; so that the carriages may not be affected by concussions and indentations received by the armour from hostile fire. The shocks sustained by the trunnion blocks are diffused over large bracket surfaces by the wrought-iron guides in which they move. The shocks imparted to the carriage are conveyed to the girders beneath through very long brackets, the cast-iron interiors of which, resting upon the wrought-iron girders form excellent friction surfaces.

35-*ton Turret Guns*. (Plate XV.)—The carriages for the 35-ton guns in the "Devastation's" turrets, differ but slightly from those for 25-ton guns in the "Glatton," and for 18-ton guns in coast defence ships. The hydraulics for lifting the 35-ton guns from step to step at the trunnions are fixed in the floor of the turret, Fig. 7, instead of to the bottom plate of the carriage as in the 25-ton and 18-ton guns. This necessitates the provision of two sets of lifting hydraulics, one for use when the gun is out, the other when it is in.

Running in Turret Guns, Fig. 7.—The power employed for running in and out the 35-ton gun is multiplied in the ratio of 280 to 1, and is applied on four handles; whereas the gear used with the "Glatton's" 25-ton turret gun multiplies the power applied to three handles 210 times; and, with the "Monarch's" 25-ton guns, 114 times on three handles. The necessity for providing increased mechanical power for running in turret guns, as compared with broadside ones, appears not to have been fully anticipated, nor is the cause very obvious, aside from moral considerations. It appears, however, that the power applied to run in and out the 25-ton broadside gun in the "Hotspur," Fig. 5, multiplies 120 times on two handles, whilst that applied to the 25-ton turret gun in "Glatton," multiplies 210 times on three handles. The same increase is observable as to the 18-ton gun. The broadside ones being run in and out by gear, multiplying 80 times on two handles; whilst the gear of the "Cerberus" class of colonial turret ships multiplies 109 times, and that of the later turret vessels multiplies 150 times on three handles. Thus, nearly twice as great mechanical power is required to run guns in and out when placed in turrets, than when mounted on the broadside.

Working Turrets.—The enormous weight of turret is turned upon coned rollers, by machinery worked by steam or by hand-power. The handles by which the latter is applied are placed on the deck outside its periphery, where the winches for running in are also placed. The "Monarch's" turrets perform half a revolution in 18 seconds when worked by steam, but take 80 seconds to do so when moved by the manual labour of 18 men. The men who control the revolutions are in the latter case out of sight of the director of the turret, and cannot observe what they are doing, nor see the motions of their director; they have, therefore, to act in blind obedience to his voice, by the inflections of which alone they can guess the urgency or the amount of motion required. Those delicate touches of training which a smart captain of a broadside gun can promptly secure by the impatient wave of his hand, cannot be so carefully given by the turret in blind obedience to the voice. Moreover, the man who aims is not the man who fires, and the main body of the turret crew are hid from the view of both, and isolated from those men who load and tend the gun. This separation can hardly recommend itself to the experience of officers who have been much under fire, and who know the value of keeping in full view every man who is working those guns on which victory depends. The average British seaman is, under trying circumstances, but flesh and blood, deriving moral support from the presence of his comrades, and stimulated by the personal observation of his superiors. To be poked away in small squads, separated in dark boxes, idly listening to the roar of an unseen battle, with little to do but think whether each concussion felt arises from a projectile opening a sluice gate for the sea, or from a ram in the act of running over their vessel, or from a torpedo projecting it piece-meal into the air, is not a condition of existence favourable to calm exertion or to great courage. The moral aspect of the service turret system is apt to be overlooked in "piping

times of peace," but it will not be forgotten by officers who have had much experience under fire.

Artillery Training afloat—It is obvious that with mechanical gun carriages skilled labour should not be, as formerly, confined to a few principal operators, but ought to be available from every man attached to the gun. To enable this skill to be acquired, all the obsolete mountings should be removed from the boys' training ships, from the Naval Reserve drill ships, and from the gunnery instruction ships, and boys and men should be trained to the use of existing appliances. By early and continuous practice with machinery, even young lads acquire great delicacy of touch and facility of execution. But working men, who thus learn chiefly through their hands and eyes, cannot be taught the use of mechanical apparatus without seeing or handling it. Moreover, in proportion as artillery increases in size and is reduced in number, eye-training acquires greater importance, and should occupy a foremost position in physical gunnery. Rapidity and correctness in ascertaining and communicating the ever-varying distance should occupy a prominent place in the preparation for battle. The influence which the sighting of guns has upon the aim when shooting with lively motion should be carefully observed, with a view to the diminution of unavoidable visual errors. Each Palliser shot from a 12-inch 25-ton gun with a battering charge, costs £6 3*s*. 5*d*., and from an 18-ton gun costs £4 9*s*., and from a 12½-ton gun costs £3 2*s*. 6*d*.; and from a 9-ton gun, costs £2 6*s*. 7*d*.; and from a 6½-ton gun, costs £1 12*s*. 2*d*. Whilst each discharge of Palliser shell is yet more costly, and that of common shell a trifle less. It seems reasonable then to expect that every pains should be taken to ascertain what is the exact distance of the target at which such costly projectiles are thrown; and to observe carefully at right angles to the range, how near they fall to the mark; and to prepare beforehand, with all care, both the eye of the marksman and the hands of his crew, to follow with the gun the devious rolling and pitching motions of the ship.

Officers, who as midshipmen, and as sub-lieutenants have mastered the various manipulations of artillery and small arms, should not, when, in after-life, they desire to study in the "Excellent" the principles of war, be committed exclusively to the teachings of foremast seamen. Nor need the course of higher gunnery education be so confined to mere manual drudgery that, even when experienced officers present themselves for the second, third, or fourth time to the "Excellent," the curriculum of artillery studies should be limited to repetitions of the merest elementary physical training. It might be fairly recognized that naval Officers who have during their whole professional career, witnessed daily the movements of heavy ordnance, and, conducted weekly general exercises, and monthly firings, have gained some rudimentary experience; and are not incapable of receiving intellectual culture in the scientific principles of the art of naval war.

The time devoted to the various arms and exercises, as well as to instruction in the principles of naval war, will be seen by the following table:—

CURRICULUM OF GUNNERY EDUCATION IN H.M. SHIP "EXCELLENT."

Subject.	Sub-Lieutenants.	"Short course" for Lieutenants.	Qualifying for Gunnery Lieutenant.	Seamen qualifying for Gunnery Instructor.	Seamen qualifying for Seamen Gunners.	Appliances, &c., in "Excellent."
	Drill days.	Drill days.	Drill days.	Drill days.	Drill days.	
Heavy rifled gun drill ..	12	23	23	46	23	Obsolete smooth-bore 100-prs. on obsolete carriages.
Truck gun drill.........	5	5	9	18	9	Antiquated truck carriages.
Revolving gun drill.....	2	—	4	8	4	Obsolete 100-pr. breech-loader.
Turret gun drill........	—	—	4	16	8	Obsolete lifting slide, &c.
Gunboat firing..........	—	—	1	6	3	Fixed 9-in. carriage without training gear.
Fuze instruction........	20′ daily	12 × 2 hrs.	9	18	9	
Examination of guns ...	—	—	1	—	—	
Infantry field exercise...	3	17	17	34	17	Landing under fire, taking cover, and all seamanlike instruction omitted.
Musketry instruction....	—	—	10	20	10	
Cutlass drill...........	15′ twice a-week	4	8	17	8	No effort to make skilled swordsmen.
Field gun drill.........	—	9	15	30	15	Landing guns, and coast warfare, &c., omitted.
Electricity.............	—	—	17	17	—	Taught by an educated Officer, but without actual naval warlike appliances.
Diving..................	—	—	1	—	—	
Theoretical subjects.....	3	—	14 × 2 hrs.	—	—	Taught by an educated Officer, but without adequate appliances.
Manual, leave, and examination	8	5	33	25	10	Examinations conducted by educated Officers.
Total gunnery......	35⅓	63	152	255	116	Battalion landing days and absences from drill not counted.
Mathematics at Royal Naval College......	—	—	141	—	—	The last six or seven of the fourteen months' course.
			293			
Average gross total in months...........	1½	3	14	18	12	Seamen are subject to many interruptions for routine ship's duties.

N.B. One-sixth of the drill time, or about two months in the year, is lost at Portsmouth, owing to the musketry instruction being given on one island about a mile off; field gun drill on another a mile in the opposite direction; infantry field exercise on a Common two miles off in a third direction; heavy gun firing seven miles off in a fourth direction; and many of the other exercises on board a variety of vessels, the squads being all out of sight of the Commanding Officer.

In rainy weather, all these drills have to be imperfectly conducted in the confined space of the "Excellent" and "Calcutta." This lack of space makes it impossible to accommodate more than a small number of the zealous Officers on half-pay who are anxious to employ their enforced leisure in undergoing the "short course" of instruction.

Economy of Gun-power.—Weight for weight the concentration of useful work or power into a few heavy ordnance has produced an economy of gun-power far beyond what the mere correspondence of weights suggests. Even when the target presents a flat surface at right angles to the trajectory; it is found impossible, in practice, to secure the simultaneous impact of numerous projectiles upon the same small spot so as to obtain united effect. And it is evident, that when the face of the target presents a considerable angle to the range, the chances of numerous shot hitting the same spot, even without regard to time, is excessively small. A vast accession of power is gained by employing the same weight of iron in a single shot, which can only hit on one spot and at one time whether the hostile ship presents her broadside at a right or at an obtuse angle. It will be remembered that a single 450-lb. smooth-bore shot from the United States' monitor "Weehawken," shattered the armoured side of the Confederate "Atalanta," and placed so many men *hors de combat* as to decide the action. This was the more remarkable as the "Atalanta's" side presented an angular target, and the shot being of a spherical form, which is unfavorable to penetration, no perforation took place. From our own experience at Shoeburyness it has been deduced that one 68-pounder of $4\frac{3}{4}$ tons weight firing one 68-lb. shot with 16 lbs. of powder produces the same effect on an armoured target as five 32-pounders of the united weight of $14\frac{1}{2}$ tons, throwing 160 lbs. of iron with 50 lbs. of powder. 17 men armed with a 68-pounder can thus do as much damage as 65 men armed with five 32-pounders. Again, it takes 1,190 men working seventy 68-pounders weighing in all $332\frac{1}{2}$ tons, and throwing 4,760 lbs. of iron, with 1,120 lbs. of powder, to match 16 men working one 18-ton gun, which throws 400 lbs. of iron, with 60lbs. R.L.G. powder. The saving of wages, provisions, and pension in employing sixteen men to do the work of 1,190 men is so great as to throw into the shade the fact that each discharge from seventy 68-pounders, costs £49, whilst that from the 18 ton gun costs only £4 9*s*., or nearly nine-tenths less money. In other words, to preserve the relative offensive powers of the "Hercules" against a similar ironclad whilst changing her eight 18-ton guns for 68-pounders of 95 cwt., that ship must have 560 port holes for an equal number of 68-pounders instead of eight as at present, and must carry 9,520 men for this one purpose if she would full-man each, instead of 128 men if it were desired to full-man the present 18-ton guns. This enormous accession of gun-power obtained by concentration of weight in few guns, forms the chief argument in favour of ponderous ordnance.*

Economy of Space.—In discussing small craft armaments, we have noticed the evils of long gun-slides in vessels of narrow beam. In ironclads, the question of space assumes another and yet more important aspect. Every additional inch of space taken up in working an armour covered gun, involves an increased distance between the ports, and calls for additional armoured side, which adds enormously to the weight carried, and consequently to the size, the cost, and the

* See Modern Carriages for Heavy Naval Ordnance, Journal of Royal United Service Institution, vol. x, No. 41, 1866.

handiness of the ship. Therefore, in economising space in working artillery in ironclad ships, we economise all the most material elements which enter into the construction and management of these costly vessels. This is what mechanical gun-carriages achieve to the utmost limit. When we contrast the dimensions and the defensive and offensive powers of our first ironclad, the "Warrior," with those of the "Hercules," it should be borne in mind how much the concentration of weight of artillery, and the introduction of mechanical gun-carriages, without which such ordnance could not have been worked at sea at all, have, by diminishing the fighting space, contributed to a reduction of the extent of armour cover, and thus enabled thicker armour and more formidable weapons to be carried by a much smaller ship.

Thus the "Warrior" is 9,137 tons weight, partially armoured, with 4½-inch plates; whilst the "Hercules" is of 8,677 tons, and has all the vital parts clothed in 8-inch armour. Yet, until recently, both ships carried the same weight of artillery, but that of the "Warrior" was divided into 32 pieces, of which 28 would have been useless at 1,000 yards against the "Hercules;" whilst that of the "Hercules" is divided into 14 pieces, of which 11 would be effective against a similar ship at that distance. Much of this advantage is gained by concentrating the weight of artillery into fewer pieces, and employing mechanical gun-slides, the shortness of which reduces the space to be covered with heavy armour.

Again, the "Royal Alfred" was armoured before mechanical gun-carriages were generally accepted, and the distance between her ports from centre to centre is 20 feet for her 12½-ton guns, instead of 17 feet as for the 18-ton guns of the "Hercules." From this cause alone the "Royal Alfred" carries about 21 square feet of armour cover per gun more than the "Hercules." If the "Royal Alfred" had been designed to carry the new complete 9-inch gun slide, which occupies 18 inches less space than the imperfect mechanical ones now on board that ship, the distance between her ports might have been further reduced 18 inches. Thus the armoured area might have been 31 square feet per gun less than at present; and this additional weight might have been otherwise employed. This extra cover necessitates a corresponding diminution of its thickness, and weakens her defensive qualities.

Economy of Men.—Mr. H. D. P. Cunningham graphically described before this Institution, in 1866,* the attempt then being vainly made by 24 stalwart seamen gunners to work with tackles and handspikes a 12½-ton gun on the level decks of the "Excellent," in the Lake of Porchester. By the introduction of mechanical appliances, twelve men can now work the same gun with ease, accuracy, and safety, in a heavy sea-way; and 17 is the maximum number that can be made to share the operations connected with the handling of a 25-ton broadside gun. Thus, in 1869, the Captain of the "Northumberland," an ironclad of 10,584 tons weight, pointed out that 751 men was the number specified by the official Quarter Bill for fighting that ship, of whom 474 were required for working her 26 guns, but that the complement allowed

* Journal of the Royal United Service Institution, vol. x, No. 39, 1866.

was 45 short of this; and he requested that the necessary additional men should be granted. By substituting, for ropes and handspikes at her 9-ton and $12\frac{1}{2}$-ton guns, the mechanical training gear suggested three years before, a saving of 48 men, or about £2,000 a year was effected; and this additional fitting was found to save so much time as well as labour in taking aim with the ship in active motion, that the Commander wrote, "You have no idea the difference our training gear makes; we "practised coming home, and got through nine rounds in about half-"an-hour's very good practice; ordinarily, it would have taken about "four hours, *i.e.*, as we have done before." A further reduction of labour and time, with increased accuracy of fire, might have been attained, had the eccentrics for the rear rollers of the slides been removed and the original design adopted, as in the most recent constructions. These rear eccentrics employ from two to four additional men, and are prejudicial to accuracy of motion. Had this been done, the labour of 100 men, at the annual cost of £3,865 13*s.* 4*d.*, might have been saved, and better results obtained from the same guns. These men would be available for manning prizes or other ships.

By diminishing the sail power of ironclads, or by applying labour-saving apparatus to the sails, or by abolishing ornamental evolutions aloft, the complements of armoured ships might, by the thorough introduction of mechanical gunnery appliances, be reduced still more. Such economy in men represents not only a saving of money, but, what is of far greater importance, an increase of power; for the same number of skilled men could be diffused over a larger fleet. This saving of men by the use of mechanical gun-carriages is a matter of no small importance to a country without adequate reserves of skilled men-of war's men. Our wealth may purchase any amount of machinery, but neither gold nor press-gang can create in an emergency human skill in the quantities requisite to maintain the only coast defence compatible with our national existence, viz., the defence of the low-water line on hostile shores.

Economy of Money.—The unhappy fact, that the present bad system of rifling destroys heavy artillery in a few hundred rounds, may be easily obviated by the abolition of the increasing strains at the muzzle, and the introduction of the iron-bearing centering system, which so much official experience has shown to be capable of affording longevity to both gun and projectile. This corrected, the gain of gun-power and the endurance of iron carriages may be set against the circumstance that each 18-ton gun costs about £1,356, and each 25-ton gun about £1,796, and that their mechanical carriages are proportionately expensive. Comparing the few heavy guns with the many small, the first cost is by no means excessive; whilst the saving of costly human labour is so remarkable, that, even if we could imagine such ponderous weapons being worked in a sea-way as accurately and safely by handspikes and tackles as with mechanical gear, the economy of wages, provisions, and pensions, represents a continuous as well as a large daily saving.

Conclusion.—In contrasting the efficiency gained by the employment of machinery for working guns at sea, with the inefficiency attendant

upon rope-worked mountings, I have dealt exclusively with accomplished facts. Omitting speculative considerations, I have described, as they now exist in Her Majesty's Fleet, the more perfect gunnery appliances of the "Hercules," "Sultan," "Blonde," and "Raleigh," the inaccurately working slides for $6\frac{1}{2}$-ton guns, and the miserable mountings of the 64-pounders and smaller guns. I have sought to gather up the experiences obtained at sea, and I find that every officer who has witnessed the working of mechanical and of rope-worked carriages in the same ship, when aiming at targets at sea, or in heavy weather, appreciates the numerous and immense advantages which machinery has over tackles, even when the weight of artillery moved is one, two, three, or four times greater. Amongst those who have thus officially eulogized mechanical appliances, or condemned rope-worked carriages, may be mentioned, the Board of Admiralty, in 1869, the late Controller of the Navy, the late and the present Directors General of Naval Ordnance, the present Captain of the "Excellent," Admirals the late Frederick Warden, G. T. P. Hornby, E. Inglefield, C.B., F.R.S., R. J. Macdonald; Captains Vansittart, C.B., Preedy, C.B., Tatham, Willes, Connolly, Luard, C.B., Lord Gilford, the Honble. F. A. C. Foley, E. H. G. Lambert, W. R. Rolland, R. Dew, Marten, J. G. Goodenough, and A. Wilmshurst—the last-named officer having been one of the first to appreciate the merits of machinery for guns.

Turning to foreign nations, we find that none have overcome the difficulties of working ponderous weapons with ease, accuracy and safety in a sea-way, excepting those which have copied Captain Scott's designs. The Chief of the United States' Ordnance Bureau, reported last year that "a large sum is required for alterations in the 10-inch and 15-inch iron gun-carriages," thus showing that the problem is still unsolved in that country. We may, therefore, safely assume that the British Navy, is, in this respect, in advance of all the navies of the world. Shall we then learn nothing from the experiences and reports of our naval men? Or, are these so unworthy of attention, that seamen must continue to be cumbered with inefficient, inaccurate, and unsafe mountings for their smaller guns when efficiency is within easy reach. We have spent much money upon rope-worked carriages which are a discredit to our seamenlike capacity; and also upon only partially effective mechanical appliances for 9-ton and $12\frac{1}{2}$-ton guns, whilst, ever since 1862, the more perfect apparatus now being tardily adopted was within reach. Surely, it is high time to cordially accept the logic of accomplished facts, to discontinue the manufacture of imperfect gun carriages, and to loyally adopt to its fullest extent and for every calibre, the very best means within our reach of "mounting and working guns at sea."

The CHAIRMAN: Gentlemen, I am sure that you have all listened with great interest to the very explanatory paper with regard to the mounting of naval ordnance which Captain Dawson has just read. He commenced by referring to the old mode of mounting guns, and working them by tackles and ropes, what he called "rope work." I am obliged to acknowledge that I was one of the few old-fashioned officers who were of opinion that guns above 95 cwt. could not be worked on board ship. But when I gave that opinion (and other officers with me), it was with the under-

standing that they could not be worked with the appliances then in use, that is to say, with blocks and tackles. There is no doubt that, without the present appliances, it would be quite impossible to work the present heavy guns. But I cannot exactly say that we ought to be sure that, in case of war, when guns are exposed to shot, we should not have to go back in some measure to the old tackles. As long as guns are mounted in ironclad boxes, or in turrets, where shot cannot get at the carriage or the gun, nothing can be more perfect than Captain Scott's plan. But if they are mounted in an exposed position, and a shot gets in among the machinery, I take it that the only way to go on working guns (if you have not done away with bolts in the ship's side), would be to get up the old tackles, and try to do the best you could in the old-fashioned way. Therefore, I cannot quite agree to throw away the old plan. With regard to the compressors, there is no doubt that Captain Scott's is far the best, and the whole system of his carriage is by far the best; still, I cannot allow that they are quite perfect. I have never commanded one of the ironclads of the present day carrying these heavy guns, but I have gone on board and seen the practice. I happened one day to be on board the "Hercules" with the 18-ton guns. I asked an Officer, "Are these self-acting compressors?" He said, "Oh no, we must attend to the compressor." "I replied, "I do not think the compressor perfect without it is self-acting," because, from my little experience in gunnery and working guns, I find that in general, even with excellently and highly-trained gunners, when they are in a hurry, they screw up the compressors when they ought not, and then do not screw them up when they ought. They told me this sort of thing never occurred now, everything was much superior to what it was in former days; the men were better trained. I was glad to hear it. However, they fired with full charges to try the effect of the new pebble powder. I was standing close to the gun. The gun came bang in about three feet beyond where it ought to come. The Officer said, "Hallo! there is something wrong here." I said, "Oh, I know there is something wrong, it is just what I told you; either the man has screwed it up too much, or he has not screwed it up at all." It was found, I believe, that the man had not screwed it up at all; and if it had not been for the buffer, the gun would have been dismounted altogether. As it was, it broke the T-plate, which Captain Dawson says is of no use. I do not think there was a hook in front of the carriage; the gun was disabled. They would not have repaired that under two or three hours. I merely mention these facts to show that we must not fly to the conclusion that everything is perfect. Again, with regard to these guns, when a ship is lying over, if the ship has no sail—for now-a-days ships have no masts, and, of course, have no sails—but she may take a roll, and if the guns are extreme trained fore and aft, I should be doubtful, if she took a heavy lurch, whether there would not be a great strain upon these cogs. Every seaman who works guns in a sea-way knows there is a great difficulty with heavy guns when they are extreme trained; they are apt to fly fore and aft. Here there is nothing but the frame that is laid down on the deck, and the brass racer. We all know that when a ship is pitching, there is an elevating movement. A gun will sometimes lift right up off the deck, off the rear trucks altogether. If the ship takes a sudden pitch, she will be inclined to lift the hook out of the lip of the front racer, and the gun will fly fore and aft. I do not say this in disparagement of the plan, but these are points that occur to me. I dare say there are other gentlemen more competent to give an opinion than I am.

Vice-Admiral Halsted: I should like to ask the lecturer a single question, viz., as to whether he has ever contemplated, or whether the lecture at all contemplates the use of muzzle-pivoting as distinct from trunnion-pivoting, with the view of reducing to a minimum the size of all ports, while, at the same time increasing materially the lateral and vertical range of training for all guns, especially broadside guns. As regards turret guns they already train laterally, through the whole 360 degrees, *i.e.*, right round the circle. They are, of course, indebted to the action of the turret for this "all-round fire," which is always available, except that where there are two or more turrets, it is not reasonable to fire one pair of guns into a turret which contains another pair of the same ship's guns. But in such a ship, for instance, as the "Glatton," such a maximum range as that stated above, is the supreme triumph of Captain Coles's great invention. She can fire her two 25-ton 600-pounders right

round the whole 360 degrees, perfectly unobstructed; but her ports are anything but minimum ports. As in the case of the "Captain," and as in the case of the "Monarch," there is an open port-space of ten inches above and below each gun of the "Glatton," through which any small-arm party with rifles, or with Gatling guns, or other mitrailleuses, may keep up a very serious fire at all times. Of course, if the gun in these "floating batteries," or the other ships named, is in its upper stage of position, so as to give the greatest amount of elevation, then there is an entire opening of 20 inches above the gun. If again, the gun is in its lowest stage of position, so as to obtain the greatest amount of elevation, (but which is not very great), then there is an open space of 20 inches below the gun through which to receive all destructive fire of that sort. I am not unaware that my own view with regard to turret-armament is, usually placed, though most erroneously, in a position of contradistinction to so-called broadside armaments; I say erroneously, for turret armament, as I well know, is in reality the most perfect broadside armament which has ever been conceived,—as witness what I have stated of the "Command of Fire" of "Glatton." I am, also, not unaware that I am thus at difference, though only apparently, from my friend the lecturer himself. But the particular question of minimum ports for maximum angles of training, vertical and horizontal, whether in turrets or in broadsides, is one which in these days is of very great importance,—nay, of vital importance,—as regards exposure to hostile projectiles. And it seems even more so in the case of turret port-holes than broadside port-holes; because the interior of the turret itself presenting, as a rule, an iron circular surface, a shot which has missed a man on first entering the port need, by no manner of means, miss him again when it comes twirling round from the other side, as we must expect that it will do, unless in the meantime it be arrested. Therefore, I believe, that no trunnion-pivoting gun with its maximum port-hole, can by possibility compete "*cœteris paribus*," against an efficient muzzle-pivoting gun with its minimum port-hole, whether the guns be mounted in broadsides or turrets.

Vice-Admiral RYDER: I should like to make one or two remarks; the Chairman alluded to the great difficulty there would be when these heavy guns were trained fore and aft, and were run in to prevent them from swinging down to leeward athwart ships when the ship lurched. I had the opportunity on board the "Hercules," off Lisbon, of watching what took place; it was on an occasion when I went on board with Sir Thomas Symonds to see these guns worked when the ship was rolling. The 18-ton guns were trained nearly fore and aft, and fired through the embrasured ports which she has for that purpose. When the guns were in for loading (because that was the dangerous time), if the ship rolled heavily, the tendencies of the guns were not to fly fore and aft, but to fly athwart ships as the ship rolled,—not to capsize, but to swing down to leeward athwart ships. The man who was working the winch, who no doubt was a selected man, a careful, steady man, who had a great deal of practice at it in smooth water, was thrown with great violence right over the winch, and jerked ten yards off; he might have been killed; that is the risk. The man begins training, there is no check, no break, and the risk, if the ship gives a lurch, is, that the winch overtakes him (very often with a *sailor* his serge frock is caught in the machinery), the man himself is thrown a considerable distance, and the gun takes charge. I spoke to Captain Scott about it, and said "this is a point of great importance, which you ought to meet." The lecturer has told us that there is a plan designed, as I understood him (he will correct me if I am wrong), by which this difficulty is to be met. He spoke of a beam-compressor on a small scale, which is to be applied. If a man has to work the winch with one hand, and has hold of the lever of the little compressor with the other, which I suppose he may have to do, I doubt whether anything of that kind, if the ship is rolling much, and the gun is in that position, will bring the gun perfectly under control. At all events, the difficulty must be met, somehow, some solution must be found for it. It is of great importance, because when we are in chase or running down on an enemy, the guns trained fore and aft, or nearly so, will be the guns that will be in principal use. A rear pivot bolt for securing the slide to the deck would be I believe the safest plan. The lecturer alluded to the difficulty in firing turret guns, if a ship had any list, of being able to command the *whole* of that large arc, which you can undoubtedly command with turret guns, when there is no list, and the ship is on an even keel. But

in case of fighting without sail, for the future, we shall not be puzzled by any difficulty of the ship having a list of one degree, or three degrees, for the ship will be almost certain to be rolling through an arc at least equal to the latter, and the mark will be brought on, in the way in which we practical gunners know it is brought on, viz., by the motion of the ship; and the cleverness of the man firing the gun is shewn in anticipating and utilizing the motion of the ship, so that when the mark is brought on by that motion he fires. On shore it is very different. On shore you point your gun accurately at the object you wish to hit, allowing something for windage, and then you are certain to hit your object. With us it is totally different, the motion of the ship brings the object on. Therefore, I think the lecturer has in this respect been a little hard on the turret gun, compared with the broadside gun. In speaking of turrets, he made some allusion to the weight of the turret, which will have to carry these heavy guns. I believe I am not overstating it in saying that a turret with 12-inch armour, with appropriate backing, to carry two 35-ton guns, will approach with the guns to very nearly 1,000 tons, at all events, it will be over 800 tons. (The CHAIRMAN: Two turrets?) No, each turret with 12-inch armour. At all events, it will reach that if you go on to thicker armour, to the armour which the great artillerists, Whitworth and Armstrong, think necessary to keep out the shot which they anticipate, being able to provide us with. This is one of the difficulties ahead of us who have advocated turrets, viz., whether we can still hope to revolve turrets of this enormous weight, *steadily* in a sea way, or whether we must seek some other way of protecting the gun than by the turret, as for instance, by fixed towers, the guns *en barbette*. This is a difficulty which will have to be met. The lecturer said, as I understood him, that one of the demerits of turret ships is, that they are not suitable for carrying troops. In so saying, he evidently has not studied the different forms of turret ships which have been proposed. Of course, we are acquainted with the turret ships we have got in our navy; if you take the "Monarch," I do not imagine she could carry many troops, I doubt whether the "Devastation" could carry many troops, but he did not mean merely that the turret ships we have got could not carry many troops; but that there was something in the "turret," which prevented your applying it to a floating body which could carry troops. I think he is wrong there, the turret can be applied to a floating hull, which can be as capable of carrying troops as the purely broadside ship. Perhaps, in his answer, the lecturer will tell us why a turret ship cannot carry troops?

Captain SELWYN, R.N.: I will ask Captain Dawson a question, which I think touches the future work before us very closely. Would he tell us what implements are now used in the way of guns and gun-carriages to train the Naval Reserve of England, and the naval gunners of England? Are they the carriages that are likely to be used in the future? or, are they managed with ropes and handspikes? Because, I think, whether these mechanical appliances be always as reliable as some think, or as little reliable as others would have them to be, it is at least wise that our seamen should be trained to understand them, not that they should be put to deal with ropes and handspikes, exclusively, until the moment when they are called upon active service, and that they should, then, be put for the first time to appliances, which it must be admitted require some considerable knowledge of their use, and great steadiness. Captain Dawson has very fairly put an objection which I have often heard in this theatre, to the question of firing through your own decks in a turret ship. You may depend upon it, in the smoke and heat of action, men do not always take such wonderfully accurate shots. They are apt to let go the gun when they are only thinking they are going to hit; and it is a very serious thing if a roll has brought your own deck between you and the object, and you send a shot through that. Moreover, we should recollect in our estimate of the comparative exposure to which Admiral Halsted spoke, that not only is there much more exposure of the whole turret, but, if you happen to have an enemy to leeward of your turret, directly your ship begins to heel over, the whole interior is open to view, open to the impingement of any shot. It is not a casemate, it is a battery *en barbette* so to speak, or very little more. It has a side above the gun, but with any inclination of ship, or to a higher placed gun than its own, the turret arrangement is such that actually when the gun is run in, it is exposed to the shot of the enemy,

without any protection. As regards the weight, I thought that question had been settled here, that you could not with the modern requirements for flotation wisely carry a deck cargo of 800 or between that and, as Admiral Ryder says, 1,000 tons for each turret, exclusive of the guns. I thought it had been shown that, even without any sails, or any modification necessary from the use of sails, that the mere fact of driving a steam vessel heavily armed, with low decks, against a sea might induce a condition which may turn that vessel over, and incline her to assume what I am sorry to say, is the normal position of every iron-clad to-day in the service that has not been ballasted, that is, "bottom upward." There is not a single ironclad vessel that we have, whose curve of stability reaches 45°, consequently, the instant she is allowed to go over beyond a certain heel, I need not say far short of 45°, the so-called curve of stability—she seeks to assume a normal position, bottom up. These "curves of stability" ought long ago to have been denominated "curves of instability;" for, then, they would have warned seamen what they must do, and what they must not do, instead of telling them broadly, "Well, your ship will be very stable up to this point, it is for you to see that no wave or other cause, ever makes her go farther." With regard to the question of the compressors, and of the mechanical inventions comprised in that gun carriage, I must draw your attention to the fact that the very finest and most essential part of the whole system is that mixture of wood and iron in the compressor. There is something much beyond what appears in it as a simple compressor. If it were all made of iron, you would utterly fail of your effect. If it were all made of wood, you would utterly fail of your effect. There is a vibration set up, which Mr. Oliver Byrne integrated for you; there is a vibration set up between those pieces of wood and iron which no other arrangement would have accomplished. Other people have tried to imitate that by a different arrangement of iron, and they have totally failed. That is a point worthy of consideration when we think—to the honour of naval gunners be it said—that a naval gunner has been the first to apply in practice that very artistic condition. As regards the question of racers, and of the liability to jump off those racers under any conditions, I do not think there is the slightest difficulty in making that rail of such a form, a T-headed rail, as that it will perfectly keep down the gun. I, not less than Lord Lauderdale, think that tackles and breechings are very good and useful things when you have not got anything else. But we have got an immunity from shot which we had not before, else we could not have these mechanical gun carriages and other labour-saving appliances which we rejoice in on board ship to-day. But I think it is worth consideration whether tackles and breechings, or any plan we can put there, if shot once penetrate the ship, would be of any value at all? I do not think, with our old wooden carriages, you could get such a gun into action at all; you could not move it in the way it is now necessary to move such enormous weights, and if the carriage is once disabled, your gun can only be regarded as *hors de combat* for that day. Therefore, we shall not have to use tackles until long after we come out of action. Captain Dawson has told us that we have a few guns in a wretched state, not of explosive bursting, but of disabled bursting; because when the subject was mentioned in another Institution the other day, Major Palliser took occasion to say that the guns that had burst in the Navy, had not burst explosively. I think nava men will agree with me that if you have only a small number of guns on board ship, it does not matter as regards the fate of the action, whether the guns burst so as to be disabled or burst explosively, even, if in the latter case, one or two of your men have been killed. I hope that the result of this discussion will be, that increased attention will be paid to mechanical appliances on board our ships. We have got an enormous amount of mechanical talent in this country. We ought to employ it, and we ought to institute much more extended, more costly experiments, that we may not have to pay for the excessively costly experiment of finding things fail, when our whole reliance is placed on their being trustworthy in action against our enemies.

The CHAIRMAN: If no other gentleman has any question to ask, I will call upon Captain Dawson to reply.

Captain DAWSON: I am exceedingly obliged to the distinguished Officers who have so kindly commented and remarked upon my paper. I have endeavoured to deal with accomplished facts, and with the practical experiences gained with actual appliances,

rather than to go into speculations of my own. Having no personal experience whatever of mechanical gun carriages, I am obliged to rely for my facts upon the opinions and information expressed in numerous official reports; and in the communications I have received from many Captains now in command, or who have been recently afloat, and from Gunnery Lieutenants and Warranted Gunners. I have thus taken my information from practical men, of ali ranks, who have had the handling of heavy guns at sea, and whose comments I have endeavoured to condense and present to you. I have merely gathered up the actual experiences of Officers on shipboard, and given you their experiences, without attempting to express unsupported opinions of my own. There has been a great deal of experience gained at sea, with reference to mechanical gun carriages, there being upwards of 300 heavy guns mounted upon them afloat. Only a few of these have the complete apparatus, as it exists in the "Sultan;" the others being more or less imperfect. It is very creditable that, considering how suddenly mechanical gunnery appliances were introduced, and that they were put into the hands of untrained seamen, who had not, heretofore, been in the habit of handling machinery of that kind, they should have managed so well that there has not been in the course of six or seven years, a single serious accident whilst working these very heavy weapons in weather, in which, in former days, we should not have dreamt of casting far lighter guns loose at all. That is a fact which speaks for itself. Incidentally, Admiral Ryder answered the noble Chairman's difficulty as to the deficiency of control over the movements of the "Hercules" 18-ton gun. It is desirable to effect the purpose of working guns, with as little machinery as possible. Experience alone can teach what is the minimum amount of machinery required. The "Hercules" was the first ship to carry 18-ton guns; and the carriages are not so perfect as the ones subsequently built. But, Lord Gilford testifies that they have been worked in gales of wind as securely as if the ship were in dry dock; and that the men of the "Hercules" have the greatest confidence in their gun carriages, even with whatever imperfections they may have. The compressors are now self-acting, though it is impossible to provide against all human ignorance and carelessness. The deficiency as to training arose from there being no controlling brake (Fig. 9, *c*, pl. XVI.) These brakes have now been provided, and I need hardly say would have been provided years ago but for the obstructions to which I referred. Until official obstructions and old prejudices were overcome, perfect mechanical appliances could only be introduced bit by bit, though they were actually designed some years ago. It is most wonderful that the "bit by bit" plan has succeeded so well, and that with so many imperfect and incomplete mechanical gun carriages in the service, so very few and such trifling accidents should have occurred; not a single accident to life having resulted as the immediate consequence of such obstructiveness. As to shot destroying machinery: if even a 7-inch shell of 115 lb. were exploded in an old wooden carriage, and another exploded in the Scott gun carriage, I think the effect would be very much the same, and that the difference would not be worth talking about. The point, however, of machinery getting out of gear from less causes has been anticipated, tackles being supplied to all ships carrying mechanical gun slides. The gun slides are also provided with suitable eyebolts, so that tackles can be made use of for the purpose of training; and no doubt in fine weather, and by quadrupling the gun's crews, they will effect their purpose in a rough and inaccurate fashion. Recently, I found on board several ironclads in the Steam Reserve, tackles placed overhead in the batteries ready for use, as in olden times. Admiral Halsted has dealt with me very tenderly, considering that my conclusions with reference to turrets were not those which the gallant Admiral has so long and so ably advocated. I had no intention of dogmatizing between the turret and the broadside; but have endeavoured to reason upon the question as a gunner, dealing solely with gunnery. I have consulted with those who have served in the "Monarch," and find that they speak very highly of turrets; whilst those who have served in the broadside ships speak highly of broadside guns.

Admiral HALSTED: Is the "Monarch" a turret ship?

Captain DAWSON: She is called a turret-ship. In dealing with turret-guns, as with the broadside ones, I have taken the experience of others. I have dealt in speculations only so far as to what the "Fury" may be expected to do when she is afloat. Admiral Halsted asks me to go into the question of "muzzle-pivoting" *versus*

"compound-pivoting." (Admiral HALSTED: I asked you if you had considered the question of muzzle-pivoting.) My statements have had reference to what actually exists on board Her Majesty's ships, and there is no plan of muzzle-pivoting existing in Her Majesty's ships. But the present system of horizontal-pivoting amounts practically to lateral muzzle-pivoting for training, which is one of the points involved. I think it would be very unwise to reduce the dimensions of broadside-ports to the size of the muzzle of the gun, even if it were possible. For it is most important that the captain of the gun should be able to see the foe. In these days, ships are apt to be turned by their helms very rapidly, bringing, in a general action, a great number of different ships in line with the sights in a very short time; and it would be very difficult, looking out from a narrow port, to tell which vessel is an enemy and which is a friend. (Admiral HALSTED: Not a narrow port.) I speak of the horizontal width. To meet that difficulty, this particular port (Plate XIV, fig. 4), has been devised for the "Sultan." You observe, it is intended to give as much lateral view as possible for aiming, whilst narrowing the port to the utmost, below the field of view. (Admiral HALSTED: That is as a broadside ship.) As a broadside ship. The question of "compound-pivoting" for a broadside ship has been thought of with the view of reducing the vertical height of the port.

Admiral HALSTED: I do not understand what you mean by "compound-pivoting." My question had reference entirely to "muzzle-pivoting."

Captain DAWSON: The object of "compound-pivoting" is to reduce the vertical height of the port. The object of "muzzle-pivoting" is to attain the same object. I object to the size of the port being reduced laterally for broadside ships beyond the present limits. I have only dwelt upon things as they exist, not as they may exist some other day. The controlling brakes for the training gear, to which Admiral Ryder refers, have been attached to the existing mechanical gun slides. The men who work the winches are evidently not the men who would control the brake. This control would be in the hands of a responsible man, probably the second captain of the gun. (Admiral RYDER: Is there one in use at sea?) Yes, they have been for some time in use in recently commissioned sea-going ships, and wherever machinery is employed, except in the gunnery, drill, and training ships. Besides the usual controlling brakes, those guns that are likely to be employed in a fore and aft line are provided with an additional self-acting brake. There is one in use in the "Hotspur;" but I do not know that that one is so perfect as it might be; a much better one has been devised. The 25-ton broadside gun in the "Hotspur" (Pl. XV, figs. 5, 6), has been used in such weather, that the First Lord of the Admiralty thought it necessary to use "extreme caution" with reference to the safety of the ship. So I suppose that the gun-slide was pretty fairly tried as to bad weather. I do not share Admiral Ryder's difficulty, as to contriving machinery to rotate a turret of 1,000 tons weight. No doubt, that would be easily overcome. Perhaps, my referring to the present turret-ships being unable to carry troops was out of my special province, which is to look upon the question from an artillery point of view. Looking at the high hurricane decks and walls of the coast defence turret-ships, I imagine that the action of the wind upon so large a balloon-shaped surface will be to heel the ship over a degree or two, and, in that case, their guns will be useless when trained upon the bow or quarter. As to the reduction of shock of recoil upon the gun-slide, and consequently upon the deck, due to lowering the height of the carriage, that may be illustrated by assuming an extreme case (Pl. XIV, fig. 1). Let us imagine a very high and very short carriage on one slide, and a very low and very long carriage on another slide. Let the gun be fired horizontally, and the shock of recoil will, in the first instance, be also horizontal. But the shock is communicated to the slide by a lever, represented by the vertical height and the length of the carriage. In the case of the very high and very short carriage, this leverage will be most powerful, tending to overturn the carriage backwards, and concentrating the effect upon a small area at the rear chock. But by lowering the trunnion and lengthening the bracket, this leverage is proportionately reduced, whilst a longer surface is provided for absorbing the recoil. You thus gain doubly, first by having a less shock on the slide, and secondly, by diffusing and absorbing the concussion. Hence the same decks and beams will sustain the firing of heavier guns by the use of low carriages and high slides than before, the trunnions being preserved at the same height from

the deck and from the water-line, in both instances. Captain Selwyn asked what gun carriage is in use for training boys. The gun-carriages employed for training boys are copies of those in use many reigns before that of Queen Anne; whilst the Naval Reserve are also trained to handle those gunnery appliances which were in use long before the reign of the same good Queen. I am told that there is in each Naval Reserve drill-ship one rope-worked slide, of a subsequent date.

Admiral RYDER: Numerous guns are worked.

Captain DAWSON: They are all worked upon antiquated trucks, excepting one in each drill-ship mounted upon the worst rope-worked slides. The seamen in the depôt ships and in the Naval Barracks are similarly trained to use antique specimens of gun mounting. Seamen gunners are trained to the use of mechanical slides in the "Excellent" and "Cambridge," but the gear is of obsolete patterns, and the guns cannot be fired from them. True, seamen gunners do fire from a 9-inch gun mounted upon a fixed slide in gun-boats outside the harbour; but inasmuch as there is no training gear, there is no controlling gear. Therefore, neither officers nor seamen, qualifying as instructors in gunnery, ever see what effect firing the gun has upon the training gear, or how the controllers are used outside the harbour, or any of the other movements connected with the management of the new mechanical gun carriages, when firing guns. The Gunnery Ships have also other gun boats for training instructors to fire from rope-worked slides. Thus, neither boys, nor seamen, nor Naval Reserve men, nor future gunnery instructors, nor officers are taught in the harbour training ships how to handle the gunnery appliances actually in use at sea. But no pains are spared to impart in the several training ships a thorough knowledge of the working of all the antiquated and obsolete gunnery apparatus. The instructors do their very best with the appliances at their disposal, and teach most admirably a great deal that they know to be utterly unpractical and useless. No one deplores this waste of teaching power more than the instructors themselves.

The CHAIRMAN: I give the thanks of this meeting to Captain Dawson for his very interesting paper. I am sure it is most interesting to all naval men, and particularly to those officers who have not been employed lately, and who are not conversant with these new appliances. I hope we shall ere long hear from him again upon the same subject. I may mention with regard to Captain Scott, that we are all much indebted to him. I believe I may say that I was the first officer who inspected his new carriage—I think it was on board the "Research"—I do not know how many years ago; I think I had the pleasure of reporting favourably of it then.

Note.—Space prevented my going into the question of "eye-training" at sea, but I was in hopes that a matter of such vital and increasing importance would have been touched upon in the course of the discussion. I regret that Captain Poore, Royal Marine Artillery, is not able to be present to explain how his miniature target follows the roll of the ship, and becomes fixed in position upon pulling the trigger line. His device appears to give all the advantages of the old lever target, with the additional gain of training the whole gun's crew to comply rapidly with the requirements of their Captain whilst taking aim. Whilst so much care is bestowed on ornamental exercises, it is a great pity that that which is of far more importance, the training of the eye, should receive such slight attention. The class of certificate given to officers and men passing out of the gunnery ships is dependent far more on a retentive memory as to weights and measures, and petty dodges of drill, than upon skill in shooting, and no means exist for combining aiming with heavy gun dumb exercise at sea.

Next in importance to the artillerist to knowing all about one's own ship, is a knowledge of the protected and unprotected parts of hostile ships. This might readily be imparted by placing in every ship's battery a few plates, shewing the armoured and unarmoured portions of various classes of foreign vessels with the smallest gun which would penetrate the several parts at 1,000 yards' range marked upon each part. Such knowledge would be far more valuable to the seaman gunner than half the figures and dodges with which his memory is loaded at present. The whole subject of artillery education in the Navy needs reconsideration, with a view to re-modelling, being at present far behind the requirements of the day and the attainments of the sister service.—W.D.

Evening Meeting.

Monday, May 27th, 1872.

VICE-ADMIRAL A. P. RYDER, in the Chair.

NAMES of MEMBERS who joined the Institution between the 20th and 27th May, 1872.

LIFE.

Call, C. F., Lieut. R.E.

ANNUAL.

Muir, W. Mure, C.B., Inspector-General of Hospitals.
Talbot, Hon. Reg. A. J., Captain 1st Life Guards.

ON THE LIGHTING OF H.M.'s SHIPS.

By Captain P. H. COLOMB, R.N.

EVERY naval Officer will readily admit the importance of the subject we are to discuss to-night, and perhaps some are partly aware of the difficulties it presents. It is one where the principles lie upon the surface, but their application in a practical form can only be attained by dint of the veriest plodding. As will be seen hereafter, successful revision of the systems of lighting now in use afloat, means victory over an infinite host of small enemies, aggravating obstructions, and wearying details: consequently it is not very easy to draw up a paper on the subject which will contain many central points of interest; yet it is well that the Journal of the Institution should contain the record of an attempt made, by order of the Lords Commissioners of the Admiralty, to improve and re-model the lighting arrangements of the Royal Navy.

The systems now in use have grown up during a long course of years, have been added to or modified from time to time as pressure was felt in one way or another; but it has not been till now that a comprehensive view of the requirements of the Navy has been taken, and that a complete system of lighting has been launched.

I think I can best introduce the subject by taking things as they are now, stating the principles which ought to govern them; how the existing arrangements offend or agree with these principles; and what is proposed in lieu.

The question divides itself into two branches: first, the production; and secondly, the distribution of light. At present we use two sources of light—colza oil lamps and stearine candles. The former are used in all engine-rooms and in the saloons of troop-ships, also in certain lights for exterior use, such as bow and masthead lanterns, &c. The latter are employed for every other purpose. It will be asked whether it is intended to substitute in the revised system any others for these sources of light? Gas, for instance, has been suggested with some plausibility. It may be hereafter that at least a portion of our ships will be lighted with coal or other gas. I know that every now and then attempts are made to introduce it into the Royal and mercantile marines of this country. No thoroughly successful effort of that kind has come directly under my notice, but hearsay evidence tells me that some success has been attained in large ships sailing out of Liverpool. The steamers of the London and North-Western Railway Company are attempting to bring gas into use; but that attempt is no guide for us, as the gas is not made on board. The objections to the use of gas afloat at present, are space occupied in its manufacture; the great probability that it can never be used in the smaller class of vessels, and that therefore we should have two systems of lighting instead of one; and lastly, the danger of explosion,—not perhaps a very remote one. But there seems to me to be a general line of argument which for the present removes the necessity of considering the gas question; that is,—as I shall I think be able to show,—that we can have from candles alone about one-third more light than we now enjoy afloat without incurring any extra expense, and probably with a very considerable saving of trouble. It is in fact not impossible that we can have a complete fulfilment of our wants in the way of light in Her Majesty's ships, without travelling beyond the sources of light to which we are accustomed, and yet show a handsome return in the shape of a saving for the Chancellor of the Exchequer. Respecting paraffin (and the astonishment I have sometimes heard expressed at our neglect of so cheap and simple a source of light!) we have two objections to make—its dirt and its danger. As to its dirt, anyone who has experience of paraffin lamps and of the facility possessed by the oil for making its escape therefrom, and who will imagine a number of them transported to one of the ships in the Channel Fleet, will see very good reason in the objection. As to its danger, we are constantly told that this can be removed by raising the temperature at which the liquid gives off inflammable gas. But if we raise this to the same point as that of colza oil, we can only burn it in colza lamps with just the same inconveniences and probably not at less cost. All that makes paraffin such a valuable illuminant is its low "flashing point," as it is technically called; and though I know of a mineral oil, whose flashing point is as high as 145° Farenheit, which will burn in ordinary paraffin lamps, such an oil would be almost explosive in the event of fire near the store.

If the question were a cheap light only, no doubt paraffin, or even colza oil, might be applied universally. But the real question is not a cheap light, but such an one as will answer all the requirements of a man-of-war; shall be simple, cleanly, easily managed, and permanent,

without manipulation. We ought to be, and would be, no doubt, quite prepared to adopt a very expensive light, provided only we could have enough of it, and its use removed all cause of complaint.

No attempt, therefore, has been made by us to employ other sources of light than stearine candles, and colza oil, where candles cannot be used: and much can be done within these sources of light.

We find on inquiry that five different kinds of wick for oil lamps, and that five (or, till quite recently, seven) different forms of candle, are employed. It is probable that these varieties are capable of reduction. A very cursory examination, moreover, shows us that there is very great waste both of oil and stearine, in two directions: oil overflows, stearine melts away and is never consumed at all; or, both being consumed, they pass off in smoke instead in of light. There may also be other waste, not of the substance, but of the light after it is produced. This we shall observe as we go on.

As I shall have frequent occasion to refer to the terms "candle-power" or "candle-light," it will be as well to remind you that light in England is measured by what are called standard candles. The standard is a sperm candle made on purpose, which consumes 120 grains per hour.

The value of a candle as a source of light for ships' use, consists in its simplicity; the permanence of its light; and its cleanliness. The objections to oil are its complication, its want of permanence, and its dirt. The loss from smoke in oil lamps is infinitely greater than from candles, and without glass chimneys, whose use is always to be deprecated afloat, there is great loss of light from this imperfect combustion of oil.

The difficulties connected with candles are the cost of their light, which may be taken as double that of colza oil when properly burnt; and the limit placed on the power of a single candle by heat. While the power of a single oil light may be almost indefinitely extended, no single candle has yet been made efficient which gives a light greater than about three standard candles. The difficulty which this creates will be understood by-and-bye.

When it is proposed to revise the candle-lighting arrangements of our ships, manifestly the first thing to be done is to get at the facts connected with those candles now in use. I will, therefore, give you the values of the five kinds of candles used generally in the Service.

No. 1 is the Police candle, giving a light of three candles, burning twelve hours and three-quarters, its light costing nearly tenpence per twenty-four hours.

No. 2, the Fighting candle, giving a light of 1·6 candles, lasting seven hours and twenty minutes, and costing rather more than 5*d.* per twenty-four hours.

No. 3, the Signal candle, whose light is only 1·3 candles, but whose cost per 24 hours is the same as the fighting candle, and which only lasts five hours and three-quarters.

No. 4, the Eight, which gives the light of one candle, burns for six hours and three-quarters, and costs 3½*d.* per 24 hours.

No. 5 is the Twenty-four, which gives the light of one candle, burns

for two hours and a quarter, but costs more than $3\frac{1}{2}d.$ per 24 hours. If we establish a figure of merit for these candles, dividing the light by its cost, we get the following order:—

Fighting candle	.. ..	= 7·8
Police "	.. ..	= 7·4
Eight "	.. ..	= 6·7
Twenty-four "	.. ..	= 6·3
Signal "	.. ..	= 6·1

So that the fighting candle is the most economical of the whole, and the signal candle the least so. These two candles, however, are precisely the same in price—9*d.* per lb.,—substance, and wick. They differ only in diameter, which is a full explanation of the phenomenon, and assures us that what ought to be light passes off in smoke. There is a relation between the size of the wick and the diameter in every candle, which, when properly adjusted, makes it perfect. If the diameter be too large, more substance is melted than the wick can take up, and we get what candle-makers call a wet cup. If, on the other hand, the diameter be too small, the supply is not great enough for the length of wick exposed, and we get a yellow, smoky flame.

Having thus ascertained the facts as regards each candle now in use, the next step is to go minutely into the expenditure of some single ship, so as to get at the amount of light actually produced. If we find this ship expending stearine sufficient to produce an ample supply of light, and being yet badly lighted, we shall know that there is waste somewhere which we may be able to turn into light. If, however, we find otherwise, we may simplify the arrangements, but we cannot give more light without spending more money. Whatever the result, if the ship chosen be an average specimen, we may apply it to the whole Navy with confidence.

Through the kindness of the Paymaster and Officers of the "Monarch" during her last commission, I was able to make this minute examination of her. I must premise that she was anything but well lighted, and that the cost in candles alone was £515 a year. She burnt annually 4,873 lbs. of police candles, costing £168; 5,282 lbs. of fighting candles, costing £197; 98 lbs. of signal candles, costing £4; 538 lbs. of eights, costing £17; and 3,643 lbs. of twenty-fours, costing £129. Taking this expenditure, and the table already mentioned, I found stearine enough was consumed to keep the light of 102 standard candles day and night, without cessation, all the year round. That sounds a great deal, but we must go a step farther to see whether it is or no. The whole space to be lighted in the "Monarch" amounts roughly to 186,000 cubic feet, and the large edition of the printed Instructions can be read midway between two candles 20 feet apart. These points may form our judgment, for a ship would not be badly lighted when the Instructions were legible in every part of her. So using them, it seems that 25 standard candles would be sufficient to light 186,000 cubic feet as proposed. It must now be remembered that only a small portion of the ship requires candle-light all the year round, most parts for but half the year, and many only for a few hours a day. On the

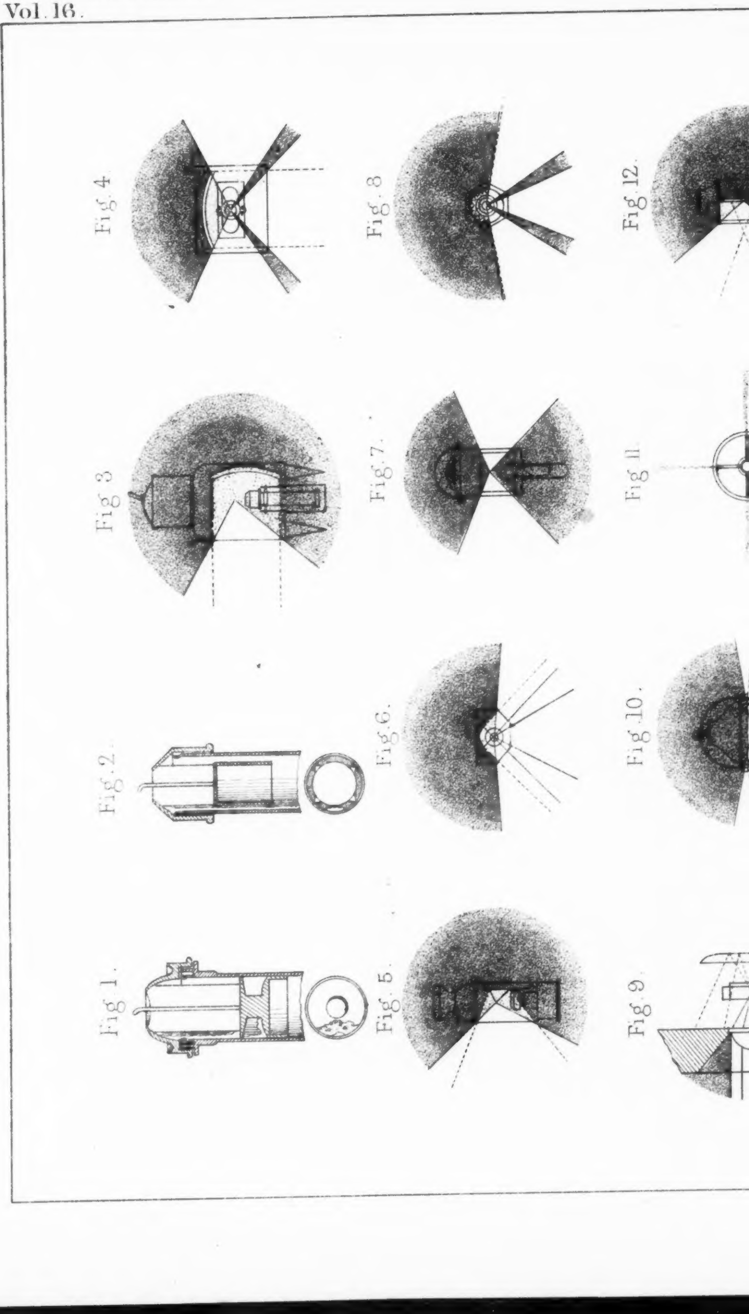
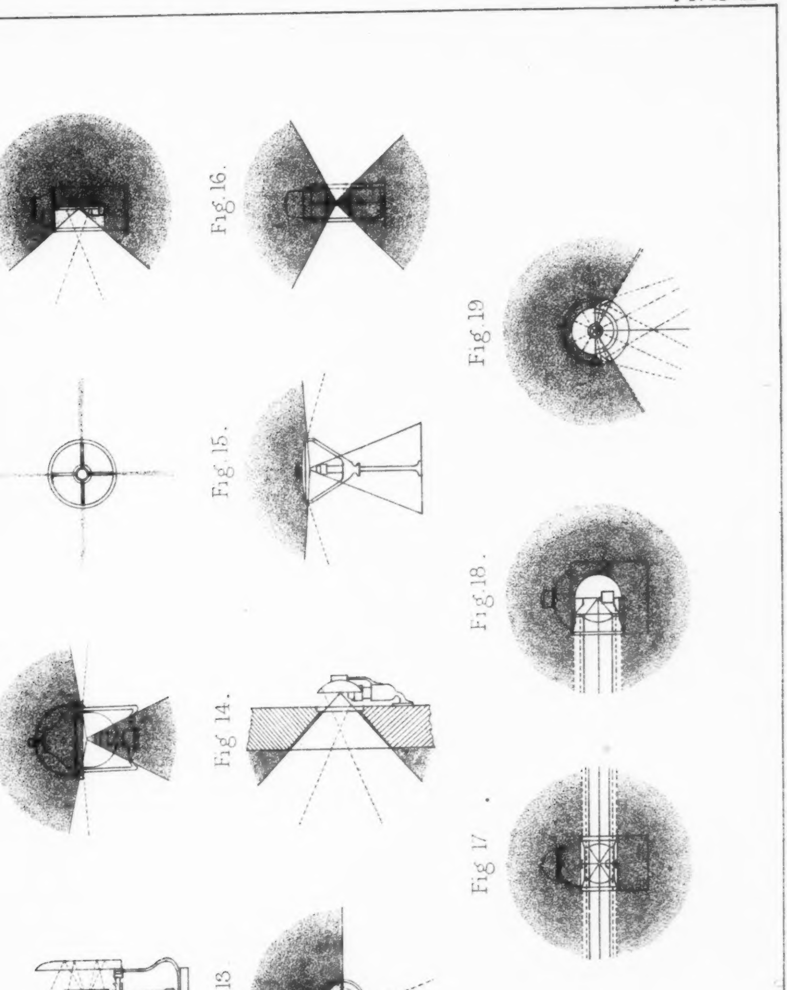


Fig. 1.
Fig. 2.
Fig. 3
Fig. 4
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8
Fig. 9.
Fig. 10.
Fig. 11
Fig. 12.

Pl. XVII.



J Jobbins

other hand, there are many parts, such as seamen's messes, which for a time want more light than that mentioned. The spaces are also very much cut up, and many objects below obstruct light. Yet, looking at it how we will, it is impossible not to be satisfied that there is in a ship like the "Monarch," and by consequence in every ship of the Navy, a very great waste of light; the stearine disposed of, ought to give ample light, and the object of our enquiry should be to trace out the loss, and turn it into illumination.

The waste may arise in the failure of the stearine to pass into light, or in the destruction of, or failure to employ to the best advantage, the light produced.

Let us take first the failure in production of light. This may either come about because the stearine is not burnt, or that, being burnt, it goes off in smoke. I have already shown, in the instance of the signal candle, how the latter waste takes place, and I need not dwell upon it longer here, than to note some loss on this head in the police candle, and to mention the remedy, which is simply to ascertain by experiment in the particular candle to be adopted, what that diameter is which will obviate all smoke.

The loss on stearine which is not burnt, is probably more important than the foregoing, and involves some practical details. We have candles fulfilling the same office which burn side by side, one of which lasts between 12 and 13 hours, and the other between 7 and 8 hours. In the "Monarch" there were something like 40 of these. It follows that the labour of replacing them is something serious. I take it as only natural that though the candles vary in their periods of burning, the lamp-trimmer's visits do not, so that practically a candle burning nearly 13 hours is only allowed to burn 12, and a candle burning more than 7 hours is only allowed to burn 6. The very obvious remedy here is to employ candles burning for the same time, which should be a measure of 24 hours.

The police and fighting candles are burnt in tubes, with a spring piston or plunger, which presses the candle up as it burns away. The pistons, as ordinarily manufactured, fit the tubes nearly tightly; as a consequence, the very smallest escape of the melted substance in the inside of the tube is sufficient to fix the plunger. The candle then burns away and is destroyed (Fig. 1). This is an accident very familiar to every one on board ship, and the remedy appears to be that shown in (Fig. 2). The plunger instead of nearly touching the tube with its whole circumference, only does so with four sharp edges or feathers. It then takes an underflow of an unusual extent to fix it in the tube. I believe this remedy is nearly perfect, and will obviate almost all the waste now taking place in this way afloat.

Signal candles we know in the old pattern lantern wasted enormously. That is remedied in those now supplied (pattern shown). There is probably very little loss on the *eights*, which are not burnt in tubes, and in any case, it would be an insignificant matter. It is different in the 24's. Government spends nearly £12,000 a-year in these candles, and probably £2,000 a-year goes in the ends. I calculate that these are the most expensive candles in use, and I must own to a particular

desire to see them disappear. If these are burnt in their appointed lanterns or sconces, one-eighth of every candle *must* be wasted, but every Commanding Officer and every Paymaster can testify that what must go to waste is a very small measure of what does. The control over their issue must be always difficult to maintain, for a ship like the "Monarch" issues 87,000 of them yearly. If we were to keep 1,900 of them burning side by side night and day for a year, we should not reach that year's expenditure in the Navy. Here again the remedy would appear to be to use larger candles in tubes, as the loss upon each would be actually less than on one of twenty-fours, and therefore, relatively very much less.

So much for the stearine which, from various causes, is not allowed to pass into light. Now for the light which from other causes is not allowed to illuminate.

We must first remember that the rays from any source of light will illuminate equally the interior of a sphere surrounding it, and of which it is the centre. Economy in the distribution of light is then obtained by diverting the rays from those directions where they are useless into those where they are useful. We very rarely indeed require light in every direction, and our ingenuity may always be applied in the process of directing it.

In the Navy there are two distinct employments to which light is put, one to make its presence visible by lighting up surrounding objects, the source of light being better concealed; the other to make its presence visible directly to the eye. All the interior lighting is included in the first class, and all the exterior lighting in the second. It will be manifest that a totally different method must be pursued in each of these two classes of requirements, and that what is the best method of developing light in one case, may prove to be the worst in the other.

If we consider where light is wanted in the illumination of a space such as a deck or compartment, we observe that it is only overhead, about the beams, where it can be spared. The deck, bulkheads, and sides, require not only light, but an equal amount of it. If it is taken away from the deck to be thrown on one bulkhead, although the light there may be twice what falls on the deck, yet the general illumination of the space will, so far from being improved, be rather deteriorated. So if light be taken from one bulkhead and thrown upon another, there there will be general loss, though one part will gain. If, however, light be taken away from overhead and transferred to the deck, sides, and bulkheads, there will be general advantage, because light is not originally required overhead.

In the case of lights for exterior use, signal-lights, &c., none of the rays which are not nearly horizontal are of any use at all, hence all other rays may be turned from their original directions into such as are nearly horizontal with the clearest advantage. In many cases, again, lights such as bow and masthead lights, do not require to be seen all round the horizon, and therefore after all the rays have been made horizontal, they may with further advantage in such cases be taken

away from those parts of the horizon where they are not wanted, and directed to those where they are necessary.

Rays of light can be turned or bent, either by refraction or reflection, but always lose some of their power in the process of bending. The power of rays, when direct, varies as the square of the distance they have travelled from the light. At 20 feet from a candle there will be only one-fourth the light there is at 10 feet; or, in other words, four candles distant 20 feet, will only give the same light as one candle at 10 feet. In the case of interior lighting, the goodness or badness of the illumination does not depend upon the actual quantity of light let out into the space, but first on the area of surface on which the light falls, and next on the condition of the eye. The electric light itself, directed into a space as a single beam, and falling on one surface in a round patch of light, will not illuminate the space so well as an Argand lamp, whose rays are allowed to fall on all sides.

No space can be illuminated better than by the light of day, and the peculiar advantage of daylight is the immense diffusion of its rays. They come from an infinite number of points in the sky, and cross and recross at an infinite number of angles; they fall on the floor and sides of the space, and reverberate, as it were, from every point at all angles. Hence there are within the space only very light shadows, and it is this absence of deep shadows which gives daylight its value, and should be imitated in artificial illumination. Again, just as it is impossible to see anything but the sun when looking towards it, so it is in a lesser degree difficult to see the objects in a space if the light which illuminates them is itself visible. The eye being prepared for the stronger rays coming from the light itself, is unable to take in the lesser rays reflected from objects.

The foregoing laws enable us to say there will be loss:—

1. When the rays are altogether stopped.
2. Whenever deflected rays are substituted for direct ones.
3. Whenever there is undue concentration of light in one source.
4. Whenever the source of light is too far removed from the objects to be illuminated.
5. Whenever concentration of the rays is substituted for diffusion.
6. Whenever the lights are so placed as to dazzle the eye.

Of course it is not possible to avoid these sources of loss entirely; the point to note is that every avoidance is an economy, and every non-avoidance a waste. Let us therefore examine the system of interior candle lighting now in use, to ascertain how far it offends against or fulfils the conditions prescribed.

This system consists of seven lanterns, or arrangements for displaying light.

1. The Police Lantern.
2. The Wing „
3. The Fighting „
4. The Magazine Light.
5. The Hand Lantern.
6. The Mess Sconce.
7. The Office Bracket.

Taking first the loss arising from entire stoppage and deflection of the rays, we shall observe that the three first lanterns in this list offend most seriously; the remainder do not require notice on this head. In Figs. 3 and 4 are given sections of the Police lantern, showing what light comes out direct, what comes out reflected, and what never comes out or is used at all. Considering the source of light as 1, we find it thus disposed of:—

Lost in the lantern	0·40
Reflected rays	0·25
Direct rays	0·35
Total	1·00

Thus only six-tenths of the light can escape from the lantern to do its duty of illumination: but even this is an over-statement. The best silvered lighthouse-reflectors absorb one-half of the light falling on them; silvered reflectors in ordinary use afloat do not absorb less than three-fourths of the light falling on them; the reflected light escaping from the lantern is thus only (say) ·07. That is to say, ·42 only of the whole light produced in the Police lantern is available for illuminating the decks.

In Figs. 5 and 6 are given similar sections of the Wing and Store-room lantern, which shows the following results:—

Lost in the lantern	0·56
Reflected rays	0·10
Direct rays	0·34
Total	1·00

Leaving, according to the estimated value of the reflected rays, only 0·37 of the light produced available for illuminating. There is, however, in this case a further loss, in consequence of the reflector being so constructed as to reflect most rays from two or three surfaces before they are suffered to escape, a loss taking place on each reflection.

In Figs. 7 and 8 are shown sections of the Fighting lantern, whose light is thus distributed:—

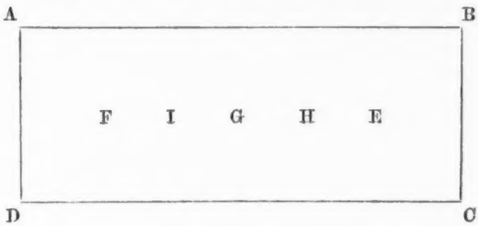
Lost in the lantern	0·65
Reflected rays	0·15
Direct rays	0·20
Total	1·00

According to the estimated value of reflected rays, it will be seen that ·24 only of all the light produced in this lantern comes out of it to illuminate the deck, and even this allowance for reflected light is much too great, owing to the elaborately improper construction of the reflector. It is so arranged that many rays are reflected as much as four times before they are finally allowed to escape, so that even were the surfaces of the finest polished silver, such escaped rays would only possess one-eighth

of the power with which they originally left the flame. The exceedingly small amount of available light from these lanterns is patent to anyone who has seen the decks of a broadside ship lighted-up for action. The want of light is then very marked.

If we apply the foregoing figures to the expenditure of such a ship as the "Monarch," we shall get some idea of the loss sustained by a defective system of lighting. She shows a yearly expenditure in the police and wing candles of £315, out of which no less than £168 appears as lost in the lanterns. If we applied the loss so calculated to the whole expenditure of these candles in the Navy, we should obtain a total loss of £7,400 a-year.

The next consideration is the position of the lights in the spaces to be illuminated, and brings us to the losses consequent on undue concentration in one spot; removal of the light too far from the objects to be illuminated; compression of rays in lieu of diffusion.



If A, B, C, D, represent the plan of a space to be illuminated, such as one side of the deck or a compartment, it would, under the existing system, be lighted either by one police light at E, or by two wing lights at E and F. Assuming that no rays are lost either in the lanterns or by reflection, and that when lights at both E and F are used, they are each half the power of that used as a single light at E; we must enquire under which of the two methods such a space would be best illuminated. If we suppose the light from the single source at E to be equal to 2 at G, the centre of the space, it will only be equal to 0·5 at F.; but if two lights, each equal to half the single light, were placed at E and F, there would be at G twice the light of 1 or 2, the same as before. Yet this would be the least light in any part of the space. Hence we see that there is a real loss wherever one large source is substituted for two small ones, and that nothing but practical considerations should limit the sub-division of the light into numerous sources.

We have seen that a light at E and another at F will better illuminate the space A, B, C, D than a single light of twice the power of either, at E. It must now be observed that these lights were as far removed as possible from any objects to be illuminated within the space, and that some light would be gained were they not so far removed, but this involves the question of reflection.

If reflection were perfect, half the light of the single source at E would be reflected towards F, so that the removal of the reflector would

diminish the light at F to ·25, and at G to 1. If the light were now moved to the central point, G, there would be the light of 1 at E and F, and no less light in any other part. Hence we may say that bringing a light from the extreme to the centre of a space to be illuminated, doubles the minimum light when reflection is perfect. As, however, one-half at least of the light is lost in reflection, it follows that one-fourth only of the whole light reaching F from E would be reflected. Hence the removal of the light at E to G would give 1·5 light to F,—three times what it had before. Placing the light centrally, therefore, really trebles the minimum light in the space.

By again subdividing the single light at G into two half-power lights placed at H and I, two points such that the light at G from the equadistant lights shall be equal to the light at E and F, we should still get better illumination than from the single light at G, for when the lights were as far off G as E and F, without reflectors, the light at G was equal to 1·5, and now that they are nearer the light, must be more than 1·5, which is also the state of the case at E and F, so that by abolishing reflection and distributing the light into two sources at H and I, we actually multiply the minimum light by more than three. We see, therefore, that even allowing the possibility of making reflected rays as powerful as direct ones, which cannot be done, the worst way in which we could go to work to light the space A, B, C, D, would be to place a single light at one end of it. The next best way would be to place two lights of half power at each end, and this would be nearly equal to putting a single light of full power in the centre. The best way would be to put two lights of half power at H and I. As, however, the two latter plans use direct, instead of reflected rays, they are both very much better than the two former.

In undue compression of rays the police lantern, and the magazine-lamp, stand pre-eminent. A reference to Figs. 3 and 4 shows how the reflected rays issue from the police lantern in nearly parallel lines, instead of radiating as the direct rays do. The light is taken away entirely from one part of the space and given entirely to another part, when both parts require an equal half share of it; the consequence is the often observed failure of the police lantern to give light into the ship's sides, and the deep shadows thrown by it.

The small amount of light in our magazine and shell rooms is often complained of, and yet the quantity and size of the candles employed to light those very small spaces is disproportionately great.

The explanation is that some serious sins are committed against the primary laws of light. In Fig. 9 is given a section of this lighting arrangement. It will be seen that the form of the reflector has no relation to its intended duty, even supposing its surface was moderately reflective, which it is not. The direct rays radiating naturally, fall upon an enormously thick lens, in which they leave behind much of their original power. They are, by means of this lens, diverted from their radial and proper course, and compressed into a bundle of rays which pass by the sides of the passage and heads of the powder cases, and illuminate either the end of the passage or the men at work in it.

Besides this, only about one-fifteenth of the light produced finds its way into the magazine, the remainder being wasted in the light rooms. It is quite possible to deal with from one-third to one-half the light produced, and thus a source of light of one-fifth to one-seventh the power of those now used, ought to illuminate as well.

When we thus pronounce against the system of lighting the decks and magazines, we must not omit to qualify our dispraise. The police lantern was designed for an Argand oil-lamp of six to eight candle-power. Such a lamp could not well be divided into several sources, and, owing to the cheapness of the light, a large waste was allowable, being balanced by other conveniences. Besides this, the police lamp was intended to illuminate long stretches of deck; and though its design could, no doubt, have been improved, all that is now counted for loss in a short compartment illuminated by candles, could not be so counted on a long deck illuminated by oil.

So also with the magazine arrangement. The passages being narrow, and compulsorily lighted from the ends, some compression of rays is desirable, but it is better that the compression should deal only with the reflected rays, leaving the direct ones to flow out radially in their full power.

We have lastly to consider the loss of produced light consequent on so placing the source as to meet the eye, and prevent its appreciating any less light from objects. This loss may be dismissed with the remark that, wherever light emanates from a point below the ordinary plane of vision, we suffer from this loss in a greater or less degree. How much, cannot be determined as a principle, but must be referred to each particular case as it arises; and they are constant on board our ships.

None of the lanterns at present in use are so made that they can be easily cleaned, and we all know the labour and time occupied in making them even decently presentable. They are all cheap in price, but are of inferior workmanship, and not calculated to last any time. Being generally made of tin, they are very liable to injury, and when injured, are valueless.

The variety of candles in use adds considerably to the clerical labour both afloat and at the Admiralty, besides all the inconveniences of proportionate supply of each kind; and is not improbably a direct source of expenditure in itself.

Having now roughly weighed all the foregoing points, and having examined closely such of them as appeared to require it, we are able to plan out what the nature of the reform should be, and what directions it should take in order to be efficient. The heads of the problem stand thus:—

1. To reduce the varieties of candles to one, or at most, two kinds.
2. To improve the tubes so as to reduce the loss in burning.
3. To design lanterns for lighting the decks and magazines, which should allow all possible light to pass out of them; which should use as little reflection as practicable, and to place them as much in accordance with theoretical principles, as the conditions of a ship will allow.

4. To construct the lanterns so that they may be lasting, and not liable to injury; valuable even when useless as lanterns; easily cleaned; and simple in character.
5. To arrange such a system of security as may, without complication, prevent fixed lights being tampered with.

In determining the sort of candle or candles, if two varieties are retained, which ought to be adopted, we have to consider that the same candles must perform a great variety of functions. They must answer for seamen's messes, hand lanterns, permanent lights on decks, the special lighting of troop-ships, signal lanterns, and, if possible, top, stern, bow, and mast-head lights; the first functions on the list requiring a weak, small light, and the latter the most powerful obtainable. But an expensive, powerful candle would not be available in messes, &c.; while it may be possible so to develop the light of a weak one, as to make it perfectly fulfil the offices of a strong light for signal purposes. We must therefore adopt for all purposes a candle of a power not greatly exceeding the smallest now employed.

I need not detail the experiments that have been made in order to secure an efficient candle for general purposes, nor the variety of substances and the make of candle, rejected after trial; it is enough to say that we finally chose for substance, a hard stearine of a light-brown colour, and of dimensions arrived at by experiment as calculated to fulfil the object. The particulars of the candle are given below:—

Substance	Light-brown stearine
Price per lb.	$8\frac{1}{2}d.$
Length	3·7 inches
Diameter	1·2 ,,
Weight	1,040 grains (about 7 to the lb.)
Wick..	42 threads
Melting point	127°
Consumption per hour ..	130 grains
Light.. .. .. .. =	1·1 standard candles
Duration	8 hours
Cost per hour	·157*d.*
Figure of merit..	7·0

This candle which is called the Deck Candle, and which was prepared by Messrs. J. C. and J. Field and Son, of Lambeth, at $8\frac{1}{2}d.$ per lb., gives a light which is rather more economical than the present Eight, still more economical than the present Twenty-four, and considerably more economical than the present Signal candle. On the other hand, it is less economical than the present Police candle, and considerably less economical than the present Fighting candle.

The candle being fixed on, the next point to consider is the method of burning it. This it is proposed to do entirely in tubes of a uniform pattern, so that any tube will fit any lantern. The loss from failure of the tube to do its duty, adverted to before, it is proposed to remedy as has been mentioned.

The next point is, a reflective surface. Silver has quite proved its incompetency; but the difficulty has been to replace it. Just at the

time I wanted it, a Company started in Birmingham and in London with a new process of plating with nickel. This metal takes nearly as high a polish as silver, with the advantage of retaining it. It does not tarnish, is nearly as hard as iron, and requires very little trouble to keep it bright. I have had two reflectors, made a year ago, lying about exposed as they would be afloat, as a matter of experiment. One is of silver and the other of nickel. The former is black, discoloured, and has nearly lost its reflective power; the other is almost as bright as when it reached my hands; neither have been washed. Were we to get nothing but nickel reflectors out of the revision of the system of lighting in the Navy, it would be a great step in advance.

We now come to the employment of the deck-candle for the permanent illumination of the decks, wings, compartments, &c., as to which the following general remarks must be made. We have seen that for the illumination of a space, such as one side of a deck, there is no more wasteful or less efficient method than that at present in use in our ships, namely, a single large light placed at one end of the space; that the next best plan was dividing the large light at one end into two of half the power, and placing one at each end, a method nearly equivalent to putting a single light in the centre; but that the best method of all would be to place two lights of half power in positions equivalent to H and I in the figure.

It happens that this falls in with the other requirements. Central lights must be placed overhead, consequently all the direct rays it is possible to employ are available, and those which would be lost amongst the beams can be reflected downwards, and so saved.

The "Deck Light," as it has been named, is designed on these principles, and if all goes well, it is hoped it may become the chief instrument for lighting the Navy. In parts it is as nearly perfect as such a thing can be, but it yet remains to be seen how it will answer afloat.

A reference to Figs. 10 and 11 will show that nearly every ray is employed in illuminating—every ray, in fact, which can be employed, and the calculation is that while the light of the present police lantern only gives 1·29 candle power for illuminating, out of a production of more than 3 candles, the deck light will give ·8 candle power out of a production of 1·1. Two deck lights on this calculation are more than equal to one police light, but three can be employed without increasing the expenditure. A ship like the "Monarch" would take about thirty of these lanterns.

The objections to this overhead system rise to one's mind at once. How is sufficient height to be obtained under the lanterns, and will not the hammocks obstruct the light? As to the first point, the full advantage of the light is obtained when the bottom of the lantern is 8 inches below the beams. This leaves ample space in most parts of the ironclads. Where there is not space, the lantern may be carried rather higher without much loss. Generally speaking, however, the lights should be placed out of the traffic, over bitts, pumps, hatchways, &c., or guarded by stanchions.

As to the hammocks, nothing short of complete trial will show how they affect the question, but remembering the value given to the rays

of a light whose source is concealed, I am of opinion that the hammocks will interfere much less than might be thought, and certainly in no way to obstruct the light. The lamps must, however, be always hung where the clews cross.

In some spaces, however, overhead deck-lights cannot be used. Then the improved wing-light (Figs. 12 and 13) comes into play. Much less light is lost here than in the present wing, but otherwise it performs the same office.

In order to obtain security for these permanent lights, an arrangement called a locking staple has been designed. It is so planned, that placing the lantern in position locks it there, and then neither candle nor lantern can be removed without the key.

In lighting the decks for fighting purposes, it is hoped an extra supply of deck lights will do all that is necessary, but this cannot be spoken of with certainty, as there is some doubt whether they will stand the vicinity of the modern explosions. If they will not, an improved fighting lantern must be constructed.

Were it not for uniformity, the only change proposed in the magazines would have been the substitution of plane glass for the lens, and proper reflectors. With the deck-candle and a proper reflector, combined with the plane glass, we ought to get a better light, although not, perhaps, very much better.

It has always appeared to me that our ships' companies' messes might be better lighted than they are. The authorised lighting for a mess is now 2 "Twenty-fours" in summer, and 4 in winter, an average of 3 all the year round. In many ships it is now the custom to supply messes with wing-lanterns and fighting candles. In one case the nominal supply is 4·4 to 8·8 hours light of 1-candle power. Practically it is much less, as we have seen. When supplied with "fighting candles," a mess gets 14·7 hours 1·6 candle light. A mess table 12 feet long cannot be said to be well lighted with 2 candles, unless some care is taken not to waste the light. A trial is therefore to be made of the mess light (Fig. 15). This is, like the deck light, intended to utilise the rays flowing upwards from the light, by turning them downwards on the table. Seamen are not easy to arrange for in matters of comfort, and have their own ways of looking at things, but I hope this plan won't give them any more trouble, but will give them a good deal more light.

The commonest and simplest-looking of all the lights in use is, perhaps, the most difficult to deal with. The existing "hand-lantern" is an object of abhorrence to me, and to, I suppose, most Naval Officers. It is always dingy, difficult to keep clean, and usually will not stay alight in a breeze. The glasses are always broken, and on foreign stations, wood or tin takes the place of glass, so that the use of a lantern becomes rather a matter of form. We have made an attempt to use talc in lieu of glass in a very much stronger lantern, but it remains to be seen how it will answer (Fig. 16).

The lighting of the engine rooms does not demand much notice here. In principle it does not show the defects already alluded to. Overhead central lighting is generally used when it is possible, and the

defects—many, it must be confessed—consist of small details without connection, and to be combatted separately.

There are now 7 kinds of lights used in our engine-rooms, 1 overhead hanging, 2 side, 1 gauge lamp, fixed, 2 hand lamps, and a safety lamp, for use in the coal bunkers. The latter is very inefficient, but it is not easy to provide a substitute. I am making an attempt to abolish chimneys—a source of much trouble—and to introduce a universal wick. The latter may certainly be done to a great extent. Nickel will here also come into play for reflection, and give increased light.

Turning to the lights for exterior use, I may take the signal-light (Fig. 17), first, as the principles introduced in it will probably be carried out in every other. Hitherto it has only been attempted to bend the rays of exterior lights in ships by simple refraction. As a ray of light cannot be so bent in a single glass lens more than 41° 49′, it follows there is theoretically an arc of 96° 42′ above and below the horizontal plane of the light which has hitherto been wasted. Practically the arc is much larger. Very few lenses are made according to rule, and the notion of a focal distance is commonly disregarded in placing the light within them. By attending to these points, I think we have a really good signal lantern, and may get really good "bow," "mast-head," "top," and "stern" lights. The plan adopted is a very simple modification of the designs of Mr. Stevenson, the engineer to the Northern Commissioners of Lighthouses, and which he called the "Holophotal System," in consequence of its using all the light possible. The lens consists of a central plano-convex part, and two bands of plane glass above and below it. All the rays that can be refracted horizontally are dealt with by the plano-convex part. Those which pass immediately above or below, go through the plane part of the lens, and are reflected horizontally, from a polished nickel surface outside the lens. Those which pass away at a still greater angle, are reflected from surfaces inside the lens, and pass out horizontally as reflected rays through the upper and lower plane bands. We thus have a central band of refracted light, and two bands of reflected light above and below. If all were perfect we should be compressing light radiating 180° into a band radiating (say) 10°, thus multiplying the power by 18. As it is there is considerably more divergence, and great absorption of rays in process of bending. With all this, however, we get out of the deck candle—the least powerful candle which has ever been used in a signal lantern—a penetration greater than any signal light we have yet had in general use.

Very great importance is justly attached to the "bow" and "masthead" lights. Those now established in the Navy are about the best I have seen, although the custom of employing paraffin increases the power of even inferior lanterns used in the mercantile Marine. Yet our lights only just fulfil the requirements of the law when the oil wicks are in perfect order, and do not fulfil them when using candles. The source of light with oil is from $4\frac{1}{2}$ to $5\frac{1}{2}$-candle power, while, as I before noticed, the largest candle made is only a little over 3-candle power. It may be possible by the use of the "holophotal system," to get out of a single candle sufficient power; that remains to be seen. And here I will show

an experimental "bow-light" which I have tried, with the view of employing the deck candle. In this case two candles are used, and by means of nickel reflectors, the light from each is concentrated into a beam, having a divergence of 6 points. The two beams are then made to overlap one point, so that horizontally the arc illuminated is 10 points, while the vertical divergence is 6 points. On trial with white glass, this arrangement has been found about equal to the Government "masthead" when burning candle, but inferior when burning oil. This agrees with the theoretical estimate, and it would appear that three deck candles so treated, would beat our present patterns completely, and give us the desideratum of bow and masthead lights, with the permanent light of candles, in lieu of the fitful light of oil. I should mention that with colour the catoptric light has totally failed, but this is only an illustration of the difficulties presented by colour. As yet no standard of measurement has been established for the shade or density of coloured glass, and a difference of tint, hardly appreciable to the eye in daylight, will immensely alter the penetration of the light through it at night. After collecting all the information I can on the matter, I am driven to a course of experiment on the penetration of coloured rays, from which, after all, I do not hope for more than some rude guide, sufficient for the practical circumstances of the case. I am also constructing a holophotal "bow" and "masthead-light" (Fig. 19), in which, having compressed the direct rays into a diverging beam of about 10° by refraction and reflection, as in the "signal-lantern," the back rays are reflected side by side with the direct. Then in the case of the bow lights, as the light is only required over a horizontal arc of 112° 30′, the light passing beyond that is reflected by means of nickel reflectors into that angle. In theory this arrangement multiplies the source of light by about 22, practically much less.

No doubt with a special candle such plans will give us, when perfect, very excellent "bow," "masthead," and other lights, but the process of arriving at perfection is tedious in all cases, and in my experience in nothing more tedious than the lighting of Her Majesty's ships.

Commander GILMORE, R.N.: I wish to remark that the direct light must always be the same in power: you cannot increase it, neither can you reduce it by refraction or reflection. (Captain COLOMB: You can reduce it.) You cannot reduce the direct light. The horizontal light must be the same, whether you apply refraction or reflection to it; you cannot take it away from itself. In the "Revenge" we had lights like that of the ordinary police-lamp. I put wings or flanges on the top of the two sides, bent up and slightly curved down afterwards. I tried them with the photometer; the refracted light was exactly the same, the reflected light was very much increased. As regards the expenditure on board ship, we all know that quartermasters have their pull of the candles that are left. That is not the measure of the loss by candles. Captain Colomb mentioned a patent lock of his. Three years ago I submitted to the Admiralty a lamp which it would be perfectly impossible for any man to open without extinguishing it on the spot. There is no lock to the lamp. It locks itself in the act of closing, and puts itself on a hair trigger; the very first time you touch the lamp to open it, down comes the extinguisher, and out goes the lamp. I proposed to the Admiralty to apply it to lamps in magazines, indeed anywhere where there was danger attending the use of lights. The Admiralty, however, have not accepted my proposal.

Captain BURGESS: I should like to ask, whether you have any particular rules with regard to the admission of air to the flame in the various lamps you have mentioned.

Commander BOYLE, R.N.: There is one thing I should like Captain Colomb to consider. No doubt he has done so. But as one who has had opportunities of judging of the practical working of ships' lamps for the last three years, I know perfectly well what the general opinion of the service in the matter of lighting is. As a rule when you commission a ship there is no "lamp-trimmer," and there is a great difficulty in getting one. Sometimes you get a man off from the shore who says he is qualified for the post. You ask him what his qualifications are, where he picked up his business, and you find probably that he has followed the plough as an introductory preparation for a lamp trimmer. He goes down and prepares himself, and after about six months he has got into the way of scrubbing the reflectors with such energy that he has got all the silver off. That is one of the main points which I think must be corrected before any system of lighting can be really efficient in the service. Then, there is another thing which will have to be considered. Of course Captain Colomb has considered it. He talks of lighting the area in the ironclad ships, but there are so many holes and corners, and it is just those holes and corners that require lighting up. If you put a light into the middle of a flat, the rays will not penetrate into the parts where you want the light to show. Therefore, the light at the end, which, though it may not contribute a greater or equal lighting power, will yet be more efficient, because it will show into more parts. Then, again, with regard to the "fighting-lantern," that is one of the most glaring things in our service. Anybody seeing a ship supposed to be lighted up for battle at night, for the first five or ten minutes may well laugh; just for the first moments when the lamps are lighted the flame burns pretty vividly, that is, if you have a good gunner who has looked out and put some spirits on the wick. But directly after that, before the wax begins to melt, there is a general "dim religious light," while everybody is waiting for the flame to burn up again before they can see to do their work. Of course that will be corrected under the new system. Further, anybody who came here to-night with the idea that there was nothing to learn from lighting a ship, may well see that he is very greatly mistaken. I have learned more than I ever thought it was possible, and I know there is a great deal more in the system which I have yet to learn, and which I shall be very glad to learn.

Commander H. W. BRENT, R.N.: I should like to ask Captain Colomb whether in the "bow-light" he has there in the two lanterns, there is not a point close to the ship, which would be four points on the bow, almost in darkness? Looking at it as it is there, it seems to me that though the rays cross by that division between the two lights, close to the ship, and even some distance from the ship, there will be a point of great darkness.

The CHAIRMAN: I should like to ask whether the reason why the old reflector was broken up into so many different parts was not that the rays were bent, and they could not pass through the candle so as to melt it; and whether, if it does pass the reflected rays through the light, it incurs any risk of heating the tube which contains the candle, and melting the candle more rapidly than it otherwise would melt?

Commander W. DAWSON, R.N.: It is so long since I, an old retired Officer, have had anything to do with the Navy, that I suppose many things have changed since those "good old times," for in those "good old times" we did not wish for any light, either moral or material. Now, it seems, there is a general wish for both, and, since darkness, moral, mental, and material has been abandoned, things seem to have changed very much. In those days there used to be a hand-lantern something like the one on the table. I remember that they used every night to serve out several candles with each lantern. One candle used to be stuck in the socket for lighting, and the other four or five were placed in the bottom of the lantern, as a sort of store. It happened on one occasion—indeed I suppose it happened more than once—but on one of the occasions when the lighted candle burned down rather too far in the socket, and set fire to all the spare candles stored in the lantern, the ship was set on fire. It happened in a store room, near the magazine, and but for its accidental discovery, the consequences might have been very serious. It would then be a very good thing if we could get rid of the necessity of issuing an extra

supply of candles, by employing one large candle to do the work of half-a-dozen small "twenty-fours." In my days we had also great difficulty in keeping these hand-lanterns in order, as they necessarily got knocked about and injured very materially. My experience agrees, therefore with Captain Colomb's in the East Indies, as to the difficulty of keeping those hand-lanterns in repair, and I shall be very glad to hear that substantial and safe hand-lanterns are supplied. As to the police lamp, my recollection is that the light used to be concentrated along the centre or clear part of the deck, whilst the messes and midship parts were quite in darkness, so that evil disposed persons might do what they liked in the messes unseen by the police. So far from being a police light, it was rather a rogue's light. If the principle, which Captain Colomb has explained to us, of dispersing the rays through the compartments were carried out, it would meet that difficulty better than the present police light. But I am not quite sure, looking over some of our present ironclads, that there would not be some difficulty about suspended lamps throwing their light below the hammocks, as the hammocks hang in some ships very far below the beams. It may be found necessary to suspend these lamps a little more below the beams than Captain Colomb at present contemplates. The magazine light was always a great nuisance to gunners, and was so shamefully placed that it gave rise at times to very great dangers. The light was concentrated entirely on one spot in the magazine, where it was not wanted, and all the rest of the magazine was in darkness. When there were half-a-dozen men in the magazine passage, the first thing was for one man to get between the light and every one else, therefore everybody in that passage but that one man worked in darkness. In emergencies it became necessary to run great risks, and to do things contrary to the regulations, the difficulty being got over by taking lanterns into the magazine itself. I have seen that done repeatedly when the exigencies of the service required it, because the lights supplied to the magazine were useless. Officers ought not to be placed in a position to incur such a serious responsibility, and involving such serious risk. Although Captain Colomb disperses the light over the passages, and has thus worked an immense improvement, he does not get over the difficulty of a man getting between the light and his comrades. It was suggested some years ago, by Lord Lauderdale, I believe, to take example from the way in which railway carriages are lighted, and to light the magazine from the roof. That would certainly overcome the difficulty I allude to, and it might be possible to do so without very great danger. Whatever little danger there may be from lighting from above would be less than the danger which now exists from being occasionally compelled to take lanterns into the magazine itself. I do not know that there is any other lantern that calls for remark from me, but I quite agree with Captain Boyle that we have learned an immense deal to-night, and I think that there is a great deal more that might be learned from Captain Colomb on the subject of lighting. I would venture to suggest that it would be a capital thing for the service if Captain Colomb were to bring out a little handbook showing, in a small condensed form, how lanterns should be managed, and the principles on which they are constructed. Such a handbook would be of great use to Officers as well as to lamp-trimmers.

Captain COLOMB: With reference to the lock, some kind of lock is necessary. The custom is to supply police and other lanterns with padlocks, but the locks disappear the first day after they come on board ship.

Captain GILMORE: But my lamp is its own lock. As you close it you lock it, you put it upon a hair trigger, and on any attempt to open the lamp you touch the small trigger, down comes the extinguisher, and out goes the lamp.

Captain COLOMB: The only objection to that is that you do not always want to put the light out. The admission of air that Captain Burgess spoke about, is a *bête noire* to anybody that has to do with lights. There are no known laws, and you can get no information in the trade. The lamp-makers have no rules whatever. Every separate lamp is a matter of experiment. But, generally speaking, I have found clearly enough that the upper exit for the air in lamps is a great deal too large, and the entrance for air below a great deal too small. It is the cause of much of the smoke which is complained of now. For instance, in the troop ships they have great difficulty in keeping the cabins and saloons clear of smoke from their candles; it is a perfect nuisance to them. One of the reasons for that smoke is, simply, that the

entrance for air in the lamps is too small, and the exit is too large. The consequence is that the air, instead of flowing upwards to the flame, flows upwards and downward in two currents from the open space above, and there is a perpetual struggle going on between those two currents; combustion is checked by the change of current, and smoke is produced. To avoid this, you must make your exit for the flame so small, that there can be no down current. But, then, the moment you have done that, you come to another great difficulty, viz., the exhaustion of the air below. Any current passing under this lamp, as it stands now, even a very slight current, exhausts the air so much that out goes the light. There is great difficulty in guarding against that. The only plan known is to put something, in the nature of a break below, so that the air, instead of passing clear across, shall strike some surface, and a part of it shall be driven up, and a part of it down. There are no rules about it. The signal lantern will take its air entirely from above. The holes are placed round the top, and then the air supplied to the flame comes down between the lens and the inner reflector, in a thin film. The exit there is in the centre.

Captain BURGESS: Have you not noticed in all the new oil lamps that there are a great many more perforations for the air to come in at than there are in the old lamps? Honey, in Regent-street, has a large collection of these lamps, which give an intense light, but they require chimneys.

Captain COLOMB: I have not noticed that. There is no doubt whatever that the exit at the top must always be very much smaller than the entrance at the bottom; but, generally speaking, it is the other way. But for lamps which have to be exposed to currents of air, such as signal lamps, I find the best way is to let the exit and extrance be close to one another; then the same current, instead of struggling in the lamp, is divided outside it, one half goes down to feed the flame, and the other half passes across the top, and forms an exhaust.

The CHAIRMAN: Will that lamp stand a gale of wind?

Captain COLOMB: As it stands now, it will go out the moment you take it into the air.

Captain GILMORE: The feature of my lamp is a cone; the air comes from three tubes round it. The oxygen is taken in over the solid cone, and it will stand any amount of draught.

Captain COLOMB: There are an infinite number of plans. The difficulty is to get at the principle, and there is none established. Captain Boyle spoke with reference to the lamp-trimmer. I perfectly agree with him, that we ought to have a better class of lamp-trimmers. Lighting is a most important thing in all our ships; we ought to have properly appointed people to look after it. But my view as to these matters is, we must not take things as they ought to be, but as they are. So the object in all these plans has been that the lamp-trimmers shall have less trouble, and shall have less to do. It will be more difficult for a man to go wrong if you extend the hours of burning the candle from seven hours to eight hours, making it a measure of the twenty-four. We suppose the number of his journeys will be limited, and that he will be able to go through his work in one journey, instead of making two or three. Then, by giving uniform tubes, every tube fitting the lanterns, he can take his round with the new tube and go on. Generally, the lamps are so made, that the amount of cleaning required is very small. We tried to make them of the simplest possible character, so that let the lamp-trimmer be what he will, he cannot very well make a mistake. With regard to the broken up spaces below, I think Captain Boyle states what is exactly right. The ironclads are particularly difficult to light, from the immense amount of broken up space below. But I think by the over-head system, and by using numerous lights and small sources of light, we are much more likely to overcome that difficulty than by using large sources of light; because, after all, this is a question of money. The reasons why our ships have not more light than they have now, is simply the cost. The cost of candles at the present time is about £30,000 a-year, and it is a cost which is continually increasing. Now, the calculation on the whole of this is, in the "Monarch"—and it is borne out in the "Hercules" and the "Sultan," as fairly as one can judge—that, at least one-third of the cost of the candles for those ships may be saved, while the ships themselves will be much better lighted. But if not better lighted, we can give them one-third more light than is now allowed them, without calling upon Government for more money. What

we have really done is to spend upon lanterns and so save upon candles. The whole of these lanterns cost from two to three times what the old ones do. The Admiralty seems to admit the reasonableness of providing strong things for the Navy, although they cost more at first. But then the calculations are based on a year's expenditure in the "Monarch," and with the new lighting she provides herself with new lanterns throughout, and saves £160 on the year, owing to the saving in the candles. Captain Brent asked with reference to the crossing of the light. The light here crosses 3 feet from the lantern; but owing to dealing with a thing of the size of a flame, and not a mathematical point, the light becomes dim at some little distance beyond that. It is a light that would show 10 or 12 feet off, and it would always be a pretty bright light. We have tested this light at a range of half a mile, a mile, and a mile and a half, and running through the whole arc of the five points. It is not perfect, still it does give a fair white light over that arc. Dim certainly towards the point right ahead, and dim a little just at the centre point. But that is all to be got over. Supposing this form of arrangement were decided upon, we should simply use three candles instead of two, and compress the rays of each candle still more. Here, we compress the rays of each into twelve points; there we compress them into seven, and of course get a very much greater power of light.

The CHAIRMAN: With the coloured glass?

Captain COLOMB: With the coloured glass. I am going to carry out a number of experiments with coloured glass, both green and red. I should put the coloured glass in each bull's eye, and not as a shade before the bar. There is little, however, known about coloured glass; there is no standard. I have consulted Professor Tyndall about it, and he informs me that there is nothing authoritative on the subject. The Chairman asked some question about reflectors.

The CHAIRMAN: The broken reflectors in the original lamps;—was not the object to avoid sending the rays through the candle?

Captain COLOMB: I do not know. I think it was done, in accordance with a notion that I find many people have, that in some kind of way the reflector generates light. But there is a difficulty such as you have mentioned about the increase of heat. I found it in the deck light. At first I sent the rays through the light; it did not destroy the wick, but I found the heat generated was extreme. Captain Dawson spoke of the hand-lanterns burning up. I have seen precisely the same thing. They carry a two hours' light, and they are sometimes further supplied with seven or eight hours' supply in the lantern, having no other place to carry it in. The lantern tumbles, and the whole of the candles and lamp burn together. That I have often seen. About the overhead light in the magazines, I quite agree with Captain Dawson; the proper way to light the magazines is overhead. But as far as I know there are difficulties in the way. Captain Harris can corroborate me, as we have gone into that matter in the "Sultan" and "Hercules;" and at any rate in existing ships there are these difficulties.

Captain GILMORE: The great objection is that the rays of the magazine light being concentrated on one spot, one man standing before the light throws the whole place into darkness.

Captain COLOMB: A great deal of that difficulty is got over by doing away with the bull's eye lens, the rays being allowed to flow out radially, they cross and recross in all directions, so that the actual amount of light in the passage is greater, though the source is small.

The CHAIRMAN: You will allow me to return your thanks to Captain Colomb for his very valuable paper, in fact, the whole service is indebted to him for the great pains he has taken on this subject. We shall all benefit by it.

LECTURE.

Friday, June 7th, 1872.

Colonel P. J. YORKE, F.R.S., Vice-President, in the Chair.

ON EXPLOSIVE AGENTS APPLICABLE TO NAVAL AND MILITARY USES, AS SUBSTITUTES FOR GUNPOWDER.

By F. A. Abel, F.R.S., Treas. C.S.

The possibility of replacing gunpowder, to any important extent, in its application to ordnance, by other explosive agents, appears at the present time as remote as it has been at any period during the history of gunpowder. No explosive mixture, or compound, for which special superiority has been claimed in point of power is so susceptible of regulation, or control, as gunpowder, with regard to the rapidity and violence of its action, even at a considerable sacrifice of the peculiar properties which are regarded as constituting points of superiority. Although very great advance has recently been made towards the attainment of control over the violence of action of gunpowder itself, when used in very large charges, it cannot yet be said that even with the most approved forms of powder which are now employed, the development of force in the largest guns is not occasionally unequal, uncertain, and intermittantly violent.

In guns of only small calibre it may, however, yet prove practicable to employ explosive agents other than gunpowder with good results, and possibly with certain special advantages. Some considerable progress was made about four years ago in the application of compressed gun-cotton to the production of cartridges for field guns, but the requisite uniformity of action, and freedom from liability to the development of injurious local pressures had not been secured when experiments in this direction were suspended, and no important attempt has since been made to replace gunpowder even in the smallest ordnance.

Partial success has, on many occasions, attended the employment, in small-arms, of explosive agents differing considerably in character from each other, but all of them more rapidly explosive, and therefore more violent, than gunpowder. The chief advantages claimed, and

more or less established for some of these over gunpowder, were in all instances the production of comparatively little or no smoke, the reduction of fouling, and increased penetrative power with the employment of smaller charges. Diminution of recoil was also frequently insisted upon as an advantage, the fact being lost sight of that this result, arising out of the greater rapidity or suddenness of the explosion, must be attended by increased local strain upon the arm, and, therefore, might constitute a source of danger. Preparations of various kinds containing chlorate of potash, together with very readily oxidisable substances, such as Horsley's powder, white gunpowder, Hochstädter's and Reichm's paper cartridges, &c., form one class of substitutes for powder, upon the application of which to small arms much time and labour has been spent, even up to recent periods, but in no instance, even before the introduction of the breech-loading arms of precision now used in military service, was powder satisfactorily competed with in regard to uniformity and accuracy of shooting at different ranges, while the comparatively great destructive effect on the arm itself was generally more or less strikingly demonstrated during brief experience with these substances. Attempts to apply gun-cotton to small arms, which were made soon after its discovery by Schönbein, in 1846, were similarly attended by results more or less disastrous to the arms employed. Many years afterwards Baron von Lenk produced a gun-cotton cartridge composed of threads arranged in firmly-plaited layers upon a core of wood, which was considered in Austria to furnish promising results, but which did not attain any position as a safe and serviceable cartridge. The Gun-cotton Committee, soon after its appointment in 1864, acquired some experience, especially through one of their members, General Hay, with several modifications of the Austrian small arm cartridge, in some of which a part of the gun-cotton charge was highly compressed in small cylinders, the remainder being in a highly inflammable condition; nothing conclusive of a favourable nature was, however, attained, though General Hay expressed himself confident as to the very promising nature of some of the results.

The reduction of the gun-cotton fibre to a fine state of division, or pulp, soon afterwards afforded several more effective means of controling the rapidity of explosion of small charges. The uniform dilution of the gun-cotton with ordinary cotton was readily accomplished, and the most explosive form of gun-cotton could also be uniformly mixed with a less explosive or more moderate variety. Messrs. Prentice originally employed diluted gun-cotton prepared by the first of these methods, the mixture being converted into sheets of stout paper, which were cut into strips of a particular weight and rolled up. Cartridges thus produced were safe and effective, provided they fitted the arm properly; but although they were to some extent successful for sporting purposes, they were far too variable in the manner in which they ignited in the gun to afford any promise of success as military cartridges. Soon after the system was devised of producing homogeneous masses of compressed gun-cotton from the pulped material, a series of experiments was carried out at Woolwich

with the Enfield rifle in the first instance, and subsequently with the Snider-Enfield. The gun-cotton cartridges employed consisted of small cylinders of the compressed material, either in its pure and most explosive condition, or mixed with some proportion of less explosive gun-cotton. Several series of good results were obtained, both with regard to velocity and uniformity, but the attainment of the same results on a repetition of the trials was uncertain. Subsequently, in 1868, a considerable improvement was made at Woolwich in regulating the explosion of a gun-cotton charge in a rifle, which consisted in impregnating the compressed charge uniformly with a small proportion of a perfectly inert substance, insufficient in quantity to affect the ultimate results furnished by the charge. This was accomplished by allowing the small cylinders of compressed material composing the charges to imbibe the requisite quantity of paraffin, stearine, or similar material, either in the form of solution, of which the solvent was afterwards evaporated, or in the melted condition, the cartridges being kept heated sufficiently long to allow a very small quantity of retarding agent to become uniformly disseminated throughout the mass. More concordant results were obtained with cartridges thus prepared than had previously been furnished by compressed gun-cotton modified in other ways, and in several instances targets were made, at 500 yards, with charges of from 26 to 30 grains, which compared very fairly with those furnished by the service ammunition. The experiments were, however, discontinued in 1868, and though the Committee on explosive substances were afterwards directed to resume the enquiry with special reference to the Martini-Henry rifle, other important work has hitherto prevented them from making more than a few preliminary experiments.

The construction of the most recent form of sporting cartridge made by Messrs. Prentice, was based upon the same principle; a slightly compressed charge, consisting of a mixture of the more and less explosive forms of gun-cotton, was impregnated with a very dilute solution of India-rubber. This substance, when deposited throughout the mass, upon evaporation of the solvent, operated like the paraffin, stearine, &c., in reducing the rapidity of explosion, and also in protecting the charge against deterioration by absorption of moisture. The principle of moderating the violence of action of gun-cotton by interposing inert, or less explosive, materials between its particles, has been carried to an extreme in the production, by Mr. Punshon, of a species of gunpowder, which consists of gun-cotton mixed with a considerable quantity of sugar and saltpetre. This mixture appears to have furnished favourable results in breech-loading small arms (with the employment of a considerably larger charge than has been used of gun-cotton to produce similar results); its uniformity of action, and its keeping qualities, when brought into competition with those of the present service small arm powder, have still to be established by thoroughly comparative experiments. The problem of producing a substitute for gunpowder for small arms, which will rival it in uniformity of range and accuracy of shooting, while retaining qualities of special value from a "service" point of view, is an exceedingly difficult one. If an explosive *compound* could be used in a fire-arm in its

integrity, and under the conditions essential for the maximum development of its explosive force, uniformity of action would be at once secured; but the suddenness of the explosion of all *compounds* renders this impossible, hence means must be resorted to for retarding their action, and they become thereby reduced to the level of explosive mixtures, their perfection, in point of uniformity of action, depending upon the mechanical perfection of manufacture, which, in the case of small arms powder, has reached so high a point as not to be readily excelled by rival processes or products. Moreover, in reducing a violent explosive agent to a level with gunpowder in regard to the moderation of its action, some of its special qualities, which appear at first sight to give it decided advantages over powder, such as high penetrative power, great reduction in the amount of charge required, perfect freedom from fouling and smoke, must be sacrificed, at any rate in part, and thus the first promise of great superiority over gunpowder in small arms is scarcely ever likely to be fully fulfilled by an explosive agent of greater violence than gunpowder. Schulze's sawdust-powder, and Punshon's gun-cotton powder, in both of which the pyroxilin is considerably diluted, are analogous illustrations of the manner in which the special properties of a particular explosive compound are to a great extent sacrificed in the production of a comparatively controllable explosive agent for projectile purposes.

By providing the naval and military service with an explosive agent considerably more powerful than gunpowder, for employment in shells, it may be hoped to combine with the superior penetrative power of the Palliser small capacity shells or cored shot, the additional destructive power possessed by shells of very large capacity, and also to supply a formidable destructive agent applicable in special instances in common shells. The chief difficulty in selecting an explosive mixture or compound suitable for such purposes from amongst the numerous violent agents with which we are now acquainted, has arisen out of the liability of most of them to violent explosion if submitted to the concussion sustained by a shell upon the explosion of the charge used to propel it. The Austrians fired without accident small spherical shells charged with gun-cotton in the form of a plait, using comparatively low powder charges; and a similar satisfactory result was obtained by the Gun-cotton Committee in experiments with 13-inch mortars. But the more violent or sharper concussion to which the shells are submitted in the rifled guns of the service, determined their premature explosion on several occasions, with eminently destructive effects upon the guns from which it was attempted to fire them. Subsequently gun-cotton in another form, and even a preparation of gun-cotton and nitro-glycerine, called glyoxiline, were safely fired from field guns, and during the late Paris siege a shell charged with dynamite was propelled without accident; but it was considered by those entrusted in England with the investigation of this subject, that a sufficiently violent explosive material might probably be selected for very advantagous employment in shells without necessarily incurring any risk of accident due to premature explosions. A series of preliminary experiments was accordingly instituted, which resulted in the selection

of a mixture of picrate of ammonia and saltpetre (termed "picric powder" by Mr. Abel), as a substance possessed apparently of sufficient violence of action, and at the same time exhibiting but very little, if any, more sensitiveness to explosion by friction or concussion than ordinary gunpowder. This mixture differs most importantly from that known as *poudre picrate*, which was experimented with in France a few years ago, and appears to have been used to some little extent by the Communists, and the manufacture of which in France was attended by more than one fearful accident. The picrate of potash, which forms the basis of the latter preparation, furnishes mixture with chlorate of potash and saltpetre, of a highly detonating character, which explodes violently when submitted to moderate friction and concussion, and which can only be manufactured with very special precautions. On the other hand, the mixture of picrate of ammonia and saltpetre, though very violent, and considerably more powerful, weight for weight, than gunpowder, remains passive when subjected to severe friction and percussion; a number of shells charged with it have been fired, without a single premature explosion from various guns, including the 9-inch gun, with a charge of 43 lbs. of R.L.G. powder. The fundamental substance in this "picric powder," called picric acid, is readily prepared at a moderate cost from a well-known and very abundant product of the distillation of coal tar, called *carbolic acid;* the powder has been proved by experimental manufacture on a considerable scale, to be readily and safely procurable by following the ordinary manufacturing operations in use at gunpowder works; and, in regard to keeping qualities, it has been proved certainly not inferior to gunpowder. Some preparations, both of gun-cotton and nitroglycerine, may perhaps prove to be safely applicable in shells, but neither of those substances are likely to furnish a material for shells so safe as picric powder; moreover, they might probably not prove in practice to be so generally efficient, inasmuch as excessive disruptive or disintegrating power may constitute a positive defect in some of the more important uses of a shell-charge.

It is in the application of explosive agents to military engineering operations and to purposes of submarine attack and defence, that the greatest progress has been made within the last six years. Gun-cotton was tried as a blasting agent in this country very soon after its discovery; and it was found so superior to gunpowder in power, that a demand for mining charges, manufactured by Messrs. Hall, at Faversham, had already arisen in 1847, and was rapidly increasing, when the production of gun-cotton in England was put a stop to by the explosion at Faversham in that year. Many explosive mixtures, of which chlorate of potash was generally a constituent, have been since proposed for use as mining and destructive agents; but no permanent position as a successful rival of gunpowder has been attained by any one of them. After the improvement which Baron von Lenk effected in the manufacture and application of gun-cotton, that substance was made the subject of extensive experiments in Austria, and it was shown, in an elaborate report prepared by the President of the Austrian Engineer Committee, Baron von Ebner, to be applicable, with decided

advantage, to several military engineering purposes, provided it was employed in a particular form and under conditions favourable to the development of its explosive force. In 1864, when the manufacture of gun-cotton was resumed in England, the Government Committee on gun-cotton obtained results demonstrating the efficiency of the Austrian form of mining charges, as a blasting and quarrying agent, especially in hard rock; the material being employed in the same way as gunpowder. The mining charges were in the form of short pieces of a compact rope, having a central perforation; they weighed very much less, and occupied a somewhat smaller space than the powder-charge required to accomplish the same amount of work. Their employment was soon found in actual practice to present decided advantages, especially for underground work (on account of the absence of smoke); provided the rock was not very soft and was free from fissures. In submarine operations, the gun-cotton rope was proved to be very decidedly superior to gunpowder, if it was enclosed in receptacles of considerable strength; hence it was adopted by the Austrians as the explosive agent for the submarine mines which they applied to defensive purposes in their last war. But the circumstance that very strong confinement was indispensable for the proper development of its explosive force, rendered it an inconvenient and uncertain material for employment in hasty demolitions and in several other military engineering operations. Strong practical demonstration of this was furnished by the repeated failures which attended the attempts of the Royal Engineers to apply charges of Austrian gun-cotton rope in connection with the demolition of the works at Corfu in 1863; although the charges were supplied by the Austrian Government in strong cases, specially constructed for the purpose.

The considerable reduction in weight, and decided, though not great, reduction in volume, of a charge required to produce a given effect in destructive operations, constituted advantages which became much more prominent when the system of reducing gun-cotton to a finely divided state, and then converting it by powerful compression into very compact homogeneous masses, was carried into practical effect in 1867. The density of the gun-cotton rope corresponded to about 30 lbs. per cubic foot, while that of the compressed gun-cotton is at least 60 lbs. per cubic foot; this difference, and the solidity throughout of the compressed gun-cotton, led to a reduction of more than one-half in the space occupied by a given weight; hence in mining and quarrying, the blast-holes could be greatly reduced in length and diameter, or a considerably larger amount of tamping could be used; and they could be placed at greater distances apart. Moreover, the smooth exterior, comparative shortness, and firmness of the charges, rendered the loading of holes easier, and the liability to accident through the jamming of the charge was considerably reduced. With respect to economy of production and consequent power of competing advantageously with gunpowder in point of price, as well as in regard to saving of time and labour, the new system of manufacture has greatly improved the position of gun-cotton, while at the same time it secures greater purity and uniformity. The necessity for employing

long-staple cotton is dispensed with, waste clippings being substituted; the purification is far more thoroughly and expeditiously accomplished when the fibre is reduced to a fine state of division, and the products of many small operations are intimately incorporated and made to furnish, upon a large scale, material of very uniform quality. Safety in transport and manipulations with the material is also very greatly promoted by conversion of gun-cotton into the homogeneous compressed form; if accidently ignited, the latter burns rapidly, but does not explode under ordinary conditions, while the gun-cotton rope or other forms of the substance at once burn explosively.

As in the case of gun-cotton in the form of rope or plait, compressed gun-cotton, if inflamed by ordinary methods, also requires strong confinement for the full development of its explosive force; hence, though its efficiency as a mining agent and for torpedoes was undoubted, its employment for many military engineering purposes presented no decisive advantage until within the last three years.

While the manufacture and applications of gun-cotton were being developed in this country, a Swedish engineer, Mr. Alfred Nobel, was devoting himself, and with great ultimate success, to the utilisation of an explosive compound corresponding in its nature to gun-cotton, a liquid substance produced from the sweet principle of oils and fats, known as glycerine, by a method quite similar to that followed in the preparation of gun-cotton. Although this substance, *nitroglycerine*, was discovered within a year of the first production of gun-cotton, no attempt was made to apply it to practical purposes, until sixteen years afterwards Nobel proposed to saturate the grains of gunpowder with this liquid, and thus add greatly to its explosive force. This scheme for utilising nitroglycerine did not lead to important results, but was speedily succeeded by Mr. Nobel's discovery of a satisfactory method of developing the explosive force of the liquid when used either in its pure state or mixed with other substances. Proceeding upon the idea that, in order to accomplish the violent explosion of nitroglycerine and analogous bodies, it was necessary to heat some portion of the mass to the exploding temperature, and thus develop an initiative explosion, Mr. Nobel suggested several methods of accomplishing this; the only really successful one, which depended for its success upon the submission of a small portion of the nitroglycerine to a sudden concussion, or species of blow, consisted in exploding a small confined charge of violently detonating powder in contact with the nitroglycerine. By this device the explosive force of the liquid was instantaneously developed and transmitted throughout the mass; confinement of the material being consequently unnecessary. This method of exploding nitroglycerine was sufficiently certain of action to render the substance susceptible of employment as an efficient blasting agent, and its liquid form, combined with its high specific gravity and insolubility in water, even secured to it some special advantages, as it could be rapidly introduced into blast-holes, and might be exploded in wet holes, or under water without any protection. But, although it was still more powerful than gun-cotton in its explosive action, its employment was soon found to involve so great a risk of accident

during transport, storage and use, as to render it an exceedingly dangerous material. Its liability to escape from a blast-hole into fissures in the rock, where it might lead to unavoidable explosions during subsequent operations of driving holes, and its leakage through any minute imperfections in the packages in which it was stored and transported, became fruitful sources of accident, which were but little affected by adopting the precaution of keeping the nitroglycerine diluted with wood-spirit until required for use; for though the solution thus produced was non-explosive, if sufficient spirit were employed, an explosive mixture of nitroglycerine and spirit was liable to separate from it when the latter became reduced in strength by evaporation through any imperfections in the packages. These serious objections to the utilisation of nitroglycerine were overcome by Mr. Nobel in 1867, when he found that it could be exploded by detonation as readily (and even with greater certainty) if mixed with solid substances, which might be perfectly inert in character, as when used in the liquid form. He was thus led to the production of solid but plastic preparations of this substance, to which he gave the name of *dynamite*. The earliest of these supplied to the public, and the one which, in its present improved form, is decidedly superior to any other nitroglycerine-preparation in point of safety in storage, consists of 75 parts of nitroglycerine held absorbed by 25 parts of a porous infusorial siliceous earth, existing abundantly in Germany, and known as "Kieselguhr." The mixture was first supplied in the form of a loose unctuous powder, from which the nitroglycerine appeared to have some tendency to separate; it is now converted by pressure into small cylindrical rolls, or charges, which are wrapped in parchment paper, and from which, as far as the lecturer's limited observation goes, the liquid exhibits no liability to exude, even upon prolonged exposure to elevated temperatures, though immersion in water will cause a separation of nitroglycerine after some time. During the siege of Paris, when dynamite factories were established at the Buttes Chaumont and La Villette, many experiments were made to ascertain what absorbent material could be best substituted for kieselguhr, which was unattainable. Kaolin, precipitated silica or alumina, sugar, and one or two other substances, were found to act very fairly as absorbent media, and eventually the ashes of Bog-head coal were employed as most efficient; but the material selected by Nobel appears undoubtedly to rank highest in its power of absorbing and retaining a very large amount of nitroglycerine. Besides the "kieselguhr" dynamite, Nobel has devised another form of the preparation (called No. 2 dynamite), which contains a much smaller proportion of nitroglycerine, mixed with finely-powdered saltpetre and resin or coal, and is intended for use as a blasting agent intermediate in character between No. 1 dynamite and gunpowder. Several other similar preparations have been devised, in all of which the porous silica has been partly or entirely replaced by solid substances of explosive or semi-explosive character. Among these, the following may be named as having received some amount of practical application; Colonia powder, which consists of a modified gunpowder impregnated with nitroglycerine; Horsley's powder, composed of his chlorate of

potash and nut-gall powder impregnated with 20 per cent. of nitroglycerine; Dualine, which may be described as Schultze's sawdust powder impregnated with nitroglycerine; Glyoxiline, which consists of a mixture of gun-cotton pulp and saltpetre, converted into porous pellets, which are saturated with nitroglycerine, and afterwards coated with varnish or other protective materials; and lithofracteur, in which the silicious earth and nitroglycerine of Nobel's dynamite are partly replaced by some explosive material, *i.e.*, by substances which fulfil the part of the gunpowder in colonia powder, or of the charcoal and saltpetre in Nobel's No. 2 dynamite. It need scarcely be said that all these preparations partake of the properties of the original dynamite, though they differ considerably in their nature. The first four consist entirely of explosive material; of these, Horsley's powder and glyoxiline probably approach most nearly to dynamite in their explosive power.

So far as the composition of lithofracteur has been made public, it is known to contain less nitroglycerine than Nobel's ordinary dynamite; the solid materials which it contains include silicious earth and sand, saltpetre, coal, and sulphur. Some good practical experiments have been made with this preparation on two occasions at the Nantmawr and Breidden Quarries, near Shrewsbury, which satisfactorily demonstrated its safety in transport and use, when in its normal condition. In this, as in all other nitroglycerine preparations containing solid materials of inferior absorbent power to Kieselguhr, freedom from liability to a partial separation of the liquid can obviously be only secured at a sacrifice of explosive power, by a reduction of the proportion of the nitroglycerine; and it is difficult to conceive that the consequent loss in power can be compensated for by the employment of solid explosive materials less violent in their action than nitroglycerine as components of the preparation.

Both dynamite and lithofracteur were used by the Prussians during the late war in some hasty demolitions, and for the destruction of guns and other operations for which compressed gun-cotton has been so successfully applied by the Royal Engineers during the last four years, and of which Colonel Fisher gave an interesting account in his lecture at this Institution in 1870.* Dynamite was extensively manufactured by the French in Paris during the latter part of the siege, and a small corps was organised and placed under the command of a "Capitaine de Dynamiteurs," who was very expert in the use of the material. Among the purposes to which it was usefully applied was the breaking of the ice when the Seine was frozen, and the consequent relief of a flotilla of small gunboats, which had become blocked in a position where they were useless. The Communists appear afterwards to have attempted to use dynamite extensively, but with no important success. Occasional serious failures in operations which were attempted both with dynamite and lithofracteur appear to have been mainly ascribable to the charges, or portions of them, having been at the time in a frozen condition.

The tendency of nitroglycerine and its preparations to freeze at a

* "Gun-cotton applied to Demolitions," by Colonel Fisher, C.B., R.E. See *Journal*, vol. xiv, page 419 *et seq.*

comparatively high temperature, and the necessity for thawing them, by application of heat, before they can be used with certainty of success, constitute a defect which, from a "service" point of view, is serious, as it cannot but interfere importantly with the safe, expeditious, and effective employment of these materials in military operations under many circumstances likely to arise in active service.

When first nitroglycerine and dynamite began to receive application, it was believed that the readiness with which they freeze, constituted a special source of danger; this belief was founded upon the well-established fact that the susceptibility to detonation of an explosive substance is in some direct proportion to the rigidity of the mass, and the consequent resistance to mechanical motion which its particles oppose to the force applied, and the opinion appeared to be confirmed by several disastrous accidents which occurred in the manipulation of frozen nitroglycerine. There is now no doubt, however, that those accidents must have arisen from specially incautious handling of the frozen material, and that the substance and its preparations are very much less easily exploded by a blow when frozen, than when in the normal state. This must, doubtless, be at any rate chiefly ascribable to the fact that the transformation into gas of the solid substance, which has been robbed of much latent heat by the freezing, must involve a greater expenditure of heat than that of the liquid in its normal condition, and hence the frozen substance will resist explosion by percussion or friction to a greater degree.

The fact that dynamite, and similar preparations, when once frozen will continue so even long after the atmospheric temperature has reached or somewhat exceeded 50°, and that they are then comparatively passive in their nature, necessitates the provision and careful application of special regulations and arrangements for thawing the material. This thawing operation may be carried out with perfect safety, but accidents have repeatedly happened in connexion with it, being due either to ignorance or want of caution, both of which are exceedingly difficult to guard against effectually in ordinary service. Moreover, the fact that this extra operation would frequently be necessary in military applications of dynamite and similar preparations, would be a source of considerable inconvenience, especially when hasty demolitions and other operations have to be carried out, in which a saving of time is of the first importance.

There is another peculiarity of nitroglycerine-preparations which cannot fail to be occasionally of considerable inconvenience in the application of those materials to service-purposes, namely, the injurious effects which they exert upon the health of persons who have to handle and use them. It is stated that the human system loses in time its susceptibility to the poisonous influence of nitroglycerine by constant contact with the material, and that the people employed in nitroglycerine and dynamite factories suffer no inconvenience after a time; sufficient experience has probably been scarcely acquired as to ultimate effects upon the constitution of those constantly subjected to the influence of nitroglycerine, but there is no question that those who have only occasionally to work with it, or its preparations, as would be the

case in their employment on service, must always be sufferers in a greater or less degree from the deleterious effects of the substance.

The perfectly innocuous character of gun-cotton, and the fact that its susceptibility of explosion is not affected by cold, render this material a decidedly safer and more convenient explosive agent for war-purposes than dynamite or other nitroglycerine mixtures. With regard to its explosive power, and its susceptibility of expeditious and effective employment in all classes of military and naval operations in which great violence of action is of special advantage, the circumstance that compressed gun-cotton may be readily exploded by detonation, places it at least on an equality with the best of those materials when used under conditions most favourable to their efficiency. In addition to its special advantages above pointed out, the transport of compressed gun-cotton in the field during active service is attended by decidedly less risk of accident than with nitroglycerine preparations. Numerous experiments have shown that both strong and light boxes containing compressed gun-cotton, as closely packed and securely confined as possible, are not exploded when penetrated by rifle bullets, the contents of such boxes are simply inflamed, but in every instance in which packages (of wood, and even of cardboard) containing dynamite and other nitroglycerine mixtures have been fired into, the result has been a violent detonation.

The great superiority of compressed gun-cotton and of efficient nitro-glycerine preparations (such as Nobel's No. 1 dynamite) over gunpowder in all operations where rapid destruction is to be accomplished, has now been most fully established. Not only would a very much larger quantity of powder be required to produce similar results, but, in some instances, it would be impossible to perform the same operations even with exorbitantly large charges of powder. This is especially the case in the breaking up of masses of hard rock and of metal (*e.g.*, large castings and forgings, guns, &c.), by the superposition of the explosive agent, or its simple insertion into cavities or perforations. Again, in tunnelling and blasting in hard rock, gun-cotton and dynamite possess advantages. Important economy is effected by their use, not merely in regard to cost of material to produce a particular result, but also in regard to saving of time, of labour, and of tools. Short charges and long tamping (which need not be hard tamping) insure the breaking up of the hole to the bottom, and generally tend to break up the rock beyond the bottom of the hole. The holes may be of comparatively small diameter, and are more rapidly loaded with the new explosive agents, especially if they are horizontal, or driven at an upward angle. In the hasty demolition of stockades, bridges, and most kinds of military works, the great importance of rapidly placing and firing the charges, renders the violent explosive agents of special value, on account of the very considerable reduction in the weight of charge required, and of the possibility of operating effectively without the aid of tamping.

Full details have been given in Colonel Fisher's interesting lecture regarding several operations of this class which have been carried out by the Royal Engineers with compressed gun-cotton, which material.

for the reasons already given, is unquestionably preferable to nitroglycerine mixtures for service applications of this kind.

As an explosive agent for submarine mines, the special advantages of compressed gun-cotton have been established already by numerous experiments. It is difficult, in the absence of direct experience of the effects produced by this material (or by dynamite) when used against ships of modern structure, to make more than an approximate estimate of the comparative effects of gunpowder and compressed gun-cotton; it would appear, however, from such experimental results as may be considered reliable, that the destructive action of the latter, when used in torpedoes, is more than four times, and more nearly six times that of an equal weight of gunpowder exploded under the most favourable conditions. Satisfactory comparative experiments with respect to the area of destruction of the two agents are still much needed.

In ordinary blasting operations in hard rock, compressed gun-cotton, and Nobel's No. 1 dynamite, appear to be about on an equality as regards power, and to furnish results equal to about six times those obtainable with an equal weight of ordinary blasting powder.

For work of this kind the particular dynamite specified, and similar nitroglycerine compositions, possess the advantage of plasticity, which admits of the more ready and somewhat heavier charging of rugged and uneven holes than with compressed gun-cotton; on the other hand, the latter requires no special treatment before use in cold weather, and is quite innocuous.

The shattering and splitting effects of dynamite and gun-cotton in hard rock are much greater than with powder; but in quarrying, the rock is generally not thrown off by them to the same extent. It is frequently found very advantageous, in rapid working, to drive large and deep holes far back from the face and charge these with the violent explosive, by which the rock is very extensively fissured; large quantities of powder are then poured into the fissures, and by its explosion enormous quantities of rock are removed. In submarine blasting, a similar mode of combining the shattering and displacing effects of the violent and gradual explosive agents has been found very advantageous. In submarine demolitions, as in the destruction of wrecks (on which subject Lieutenant Jekyll, R.E., delivered an interesting lecture at this Institution in 1869),* the violent explosives generally have a very decided advantage; but in some operations upon iron ships it has been found that the lifting effect of very large charges of powder is advantageous in clearing away framework and other parts which have been shattered but not actually removed by the violent explosive agents.

When a very moderate clearing and separating effect is required, accompanied by as little local action as possible, gunpowder cannot at present be advantageously replaced, and in earth-mines, where great displacing action is required, gunpowder has the undoubted advantage. In the submarine blasting of very soft rock, such as soft limestone or chalk rock, the comparatively instantaneous action of the violent explosion operates disadvantageously in regard to their displacing power.

* See *Journal*, vol. xiii, page 395 *et seq.*

As an illustration of this, some experiments made under Mr. Hawkshaw's direction, in June, 1870, upon the foreshore, near the Shakspeare Tunnel, at Dover, may be referred to. The object was to ascertain whether the detonation of gun-cotton charges, placed upon the surfaces of submerged soft chalk rock, would break up the latter to such an extent as to facilitate the rapid removal of the rock by dredging. The results showed that the rock was completely disintegrated, or pounded into a plastic mass like clay, within a comparatively limited area; but that the shattering or rending of the rock did not extend to any considerable distance, as it would have done in the case of hard rock, of which the portions contiguous to the charge would have presented greater resistance to the blow exerted by the extremely rapid explosion.

The degree of safety with which explosive agents may be produced on a large scale is an important consideration connected with their extensive application. The fact that the manufacture of gun-cotton, as now carried on, involves not the slightest risk of explosion up to the final stage when the material is dried, distinguishes it from most other explosive agents. In gunpowder manufacture, liability to explosion exists throughout all the operations from the point when the ingredients are mixed; and with regard to nitroglycerine, it appears that, up to the present time, occasional severe accidents during manufacture have been inevitable; they probably arise chiefly from occasional neglect of essential precautions during the several manipulations with the explosive liquid. The immunity enjoyed by gun-cotton is due to its being wet, and therefore absolutely uninflammable, throughout all stages, even after it leaves the machine in which it has been compressed into cakes or disks. At this point it contains 15 per cent. of water, the expulsion of which by desiccation is unattended by any liability to explosion, or even to ignition, if very simple precautions are adopted. For purposes of storing large quantities with absolute safety, it is very convenient to preserve the compressed gun-cotton in the moist condition, as it is delivered, in fact, from the presses. It has been stored damp for very long periods, without any detriment, and its non-inflammability in this condition is aptly illustrated by the fact that the perforations required in some of the charges are produced by drilling the damp gun-cotton, in which operation the drill used revolves at the rate of about 600 revolutions per minute. The gun-cotton employed in some extensive experiments recently made at Hastings, had been stored in the damp state for nearly nine months, and was dried partly in the open air, and partly in a hot-air chamber, when required for use. On that occasion 6 cwt. of the damp gun-cotton, packed in 24 strong wooden boxes, were stored in a wooden shed, and surrounded by inflammable material. The building was then fired, and soon burned fiercely; it continued to do so for about half-an-hour, when the fire gradually subsided, and the building and its contents were entirely consumed; the gun-cotton must have burned away gradually, as the surfaces of the masses became sufficiently dry, but at no period of the experiment was there even any burst of flame, due to rapid ignition, perceptible.

One most important consideration connected with the possibility of extensively employing an explosive compound or mixture as a substitute for gunpowder is the question of its stability. Mixtures of saltpetre or potassium chlorate with oxidisable substances of stable character, may be generally relied upon to equal gunpowder in their unalterable nature under all conditions of storage and use in different climates; deterioration in explosive power by the absorption of moisture is the only prejudicial result which generally attends long-continued keeping of such mixtures. There are a few instances, however, in which absorption of moisture may in time establish slight chemical action between the compounds of such mixture, and thus become not only a cause of more serious deterioration, but also a source of danger, as chemical activity, if once started in preparations of this kind may gradually increase, being promoted by the heat developed, until it may attain a violence resulting in the spontaneous ignition or explosion of the mass.

Although the stability of *compounds* which are endowed with explosive properties, may be perfectly reliable when the substance is in a chemically pure condition, it is susceptible of being seriously affected by comparatively minute causes, hence the most scrupulous care in the production and purification of such substances is imperatively necessary, and in this respect they compare disadvantageously with gunpowder, as a want of care in the production of the latter, though it may lead to accident during manufacture or to inferiority of product, will not affect the stability of the material.

Both nitroglycerine and gun-cotton, when prepared in small quantities and carefully purified, have been long known by chemists to be subject to very gradual chemical change when exposed frequently to sunlight, and also to be liable to slow or rapid decomposition if exposed to temperatures considerably higher than occur as extremes under natural conditions in any climate. Both are also well known to have exhibited great stability under normal conditions of preservation, and even when continually exposed to light; but though many specimens exist, which have remained unaltered almost since the first discovery of these bodies a quarter of a century ago, the instances are numerous in which laboratory specimens have undergone spontaneous change with more or less rapidity.

The apparently variable nature of these substances as regards stability, is due to the retention by them, in some instances, of small quantities of comparatively unstable impurities derived from foreign matters contained in the cellulose or glycerine; exposure to heat or sunlight developes changes in these, resulting in the production of acid substances; hence, if they exist in gun-cotton or nitroglycerine, they may constitute the starting point of decomposition when these are exposed to high temperatures or to the influence of sunlight. If they exist in gun-cotton, they will be, to some extent, enclosed in the hollow fibres, and are then only removed effectually by breaking up the latter, and long continued washing. In nitroglycerine they are held obstinately dissolved by the liquid, and their removal can also only be effectually accomplished by a long protracted washing of the very

finely-divided substance. Alkaline agents are in both cases useful in accelerating purification.

For many years nitroglycerine was universally regarded as specially liable to spontaneous change; even samples of different quantities of several pounds each, which, within the last four years, were produced at Woolwich in immediately successive operations, all apparently under the same conditions and with the special object in view of obtaining a thoroughly purified material, have exhibited great differences in their keeping qualities. They have all been preserved in the dark, side by side; some are in their originally pure condition; others have become more or less strongly acid, and two or three have undergone complete metamorphosis into oxalic acid and other products. The manufacturing and purifying processes, as perfected by Mr. Nobel, appear to furnish more reliably uniform products than those usually obtained on a small scale, and such specimens of these products as the lecturer has had an opportunity of examining, have exhibited great stability. Yet, if it were possible to trace explosions to their cause more frequently than is the case, an accidental want of stability might perhaps have been found, in some instances at any rate, auxiliary in bringing about the violent nitroglycerine explosions which have occurred. It has, however, been already established by very extensive experience during the last three years, that nitroglycerine is a far more reliable material than was formerly believed, and that if the most scrupulous attention is paid to its purification, and is combined with vigilance during storage and use of its preparations, and the adoption of certain precautions, which have already been proved important safeguards against chemical change in materials of this class, the risk of accident is so greatly reduced as to warrant the extensive manufacture and employment of nitroglycerine preparations under restrictions similar to such as may be deemed sufficient in the case of other explosive agents.

The causes which led to the great uncertainty with regard to stability exhibited by gun-cotton in the earlier days of its history, have been discussed by the lecturer in former discourses. The important improvements, in point of uniformity of composition and stability, effected by the labours of von Lenk, were considerably added to when the system of reducing gun-cotton to pulp was thoroughly developed as a manufacturing process. But the very extensive experiments and observations which were set on foot nine years ago by the Government Committee and have been continued to this day, on the keeping qualities of gun-cotton prepared by the Austrian process, have furnished most satisfactory results; very considerable quantities of gun-cotton in a great variety of forms have been stored at Woolwich for several years, and their periodical examination has failed to afford any reason whatever for doubting the stability of gun-cotton under all conditions of storage which are likely to occur. The experience thus gained applies even more favourably to gun-cotton manufactured according to the system lately in use, whereby the uniform purification of the gun-cotton is more effectually secured. Compressed gun-cotton has not only been stored extensively in different parts of Great Britain, it has also been exported in considerable quantities to Australia, the West

Indies, South America, and other distant countries, and has been used under circumstances specially trying to any material of uncertain stability.

The explosions which occurred at Stowmarket ten months ago, had the natural effect of dispelling from the public mind the great confidence which was becoming very generally entertained in the stability of gun-cotton as now manufactured. Fortunately, the facts which were elicited in the course of the consequent enquiry, constituted so complete a chain of evidence, as to place the first cause of the explosion beyond any reasonable doubt, and to demonstrate that it was quite independent of any want of stability of the properly manufactured material. A supply of gun-cotton delivered from the works at Stowmarket, forming part of a quantity of which there remained a store in the magazines that exploded, was found to contain a proportion of disks in a highly impure condition. The proportion of free (sulphuric) acid existing in some of these was so considerable, that it could not possibly have been left in the gun-cotton after the first rough washing which it receives immediately on removal from the acid, and *before* it is converted into pulp in the rag-engines, where it is beaten up for several hours with a very large volume of water. Supposing, therefore, that the gun-cotton pulp out of which these disks were formed had been submitted to the compressing process without being passed through the intermediate and principal purifying operation, it could not possibly have contained even a small proportion of the sulphuric acid which was discovered in the impure disks, and the same would have been the case even if the *un*pulped gun-cotton, after the preliminary washing and wringing, could have been converted into compressed disks. It was indisputably established therefore that the sulphuric acid discovered in the impure samples, and which could not have been generated by any decomposition of the substance, must have found its way into the finished material in some manner totally unconnected with the process of manufacture, and that no amount of carelessness in manufacture, even to the extent of partial omission of the purifying processes, could have led to the existence of the acid found in the impure gun-cotton. That this impurity was sufficient to establish rapid change, was sufficiently proved by the condition of some of the disks; and, that this chemical change, accelerated as it was by the great heat of the weather at the time, gave rise to a development and accumulation of heat inevitably culminating in the ignition of some portion of the stored gun-cotton, was readily demonstrated by simple experiments with some of the impure disks themselves. But, although the *ignition* of the store of gun-cotton in the slightly-built magazines at Stowmarket was completely accounted for, the very violent character of the explosions, and especially that of the second explosion of a small store which was burning for a considerable time before its contents detonated, were results quite unexpected to those well acquainted with the properties of gun-cotton in the compressed form. Many practical experiments had demonstrated that it might be submitted to extremely rough treatment without any risk of explosion, and single packages of the closely confined material had been repeatedly ignited, from both within and without, no other

result than an inflammation and a rapid burning of the gun-cotton having ever occurred. These demonstrations of the apparent immunity from explosive properties of compressed gun-cotton, unless very strongly confined or fired by detonation, appeared to be convincingly confirmed by the results of a somewhat extensive experiment made at Woolwich in March, 1871, with gun-cotton packed in firmly closed very strong wooden boxes of the kind which Government proposed to use for storing the material. Eight such packages, each containing 28 lbs., were enclosed in a pile of similar boxes loaded to the same weight, and the contents of the centre box were ignited; no explosion resulted, and the contents of some of the boxes even escaped ignition. A second experiment, in which the centre box was surrounded by inflammable matter, so that a fierce fire burned in the centre of the heap for many minutes before the contents of that box ignited, was also unattended by any approach to an explosion.

The apparently conclusive nature of these experiments undoubtedly encouraged a false confidence in the non-liability to explosion of stores of gun-cotton in the event of accidental ignition; and the explosions at Stowmarket demonstrated the imperative necessity for a more extensive investigation of the subject. The results of some experiments recently instituted near Hastings by the Government Committee on Gun-cotton, have already served to throw great light upon the manner in which those explosions were brought about. In the first instance, 24 boxes (containing 6 cwt. of gun-cotton) of the kind used in the earlier experiments, were stored upon tables in a small wooden shed of light structure, and a heap of shavings and light wood was kindled immediately beneath the boxes, two of which were left partly open. After the fire had been burning for about seven minutes, the gun-cotton inflamed, and continued to burn with very rapidly increasing violence for nine seconds, when a sharp explosion occurred. A very similar result was furnished by a second experiment, in which an equal number of boxes of gun-cotton was stored in a small magazine of stout brick work. By subsequent comparative experiments it was judged that a considerable proportion of the gun-cotton had been burned in both instances before the explosions occurred, but these were, nevertheless, of such violence as to produce large craters in the shingle on the side of the buildings, and to project the débris with much force to considerable distances. Two repetitions were afterwards made of the first experiment, in wooden sheds of similar structure, and with corresponding quantities of gun-cotton similarly arranged in boxes of the same size, and fastened down just as securely as those used in the former experiments, but the boxes were made of somewhat thinner wood, and were constructed less strongly. In neither of these experiments did an explosion occur. In the one instance the fire was burning in the building for more than half an hour before the gun-cotton became ignited, and three minutes after the first great blaze had subsided, there was a second blaze of gun-cotton; although the latter must have been exposed to intense heat, no explosion was produced. In the second experiment the gun-cotton burned in three successive portions, the last having been exposed for many minutes to a very fierce heat, yet burning non-explosively.

The first two of these experiments demonstrated that if, in a store containing packages of gun-cotton in somewhat considerable number, the material became accidentally inflamed, the intense heat developed by the burning gun-cotton in the first instance might raise some portion, still confined in boxes, to the inflaming point, and that the mass of the confined gun-cotton being in a heated condition, the ignition would then proceed with such rapidity as to develop the pressure essential to explosion while the gun-cotton was yet confined, the explosion being then instantaneously transmitted to other boxes.

When the magazines at Stowmarket exploded, a large volume of flame was observed to precede the explosion by a very distinct interval.

The two other experiments described appeared to demonstrate that *with such quantities* of gun-cotton as were stored in the experimental sheds, the fact of the material being confined in boxes of comparatively light structure constitutes a safe-guard against explosion, the reason being that the weaker packages are opened up by comparatively feeble pressure from within; hence, when the contents of a box become raised to the igniting temperature, or become ignited by the penetration of flame to the interior, the pressure developed by the first ignition is not sustained by the box to a sufficient extent to bring about explosion.

On the occasion of the Stowmarket catastrophe there were two store-sheds containing gun-cotton packed in boxes of light structure, which were ignited by the first explosion, and burned out without exploding, while a third, which contained gun-cotton packed in the strong Government boxes, exploded with great violence after having been in flames for some time.

Simple experiments demonstrate that if any explosive compound or mixture be ignited when in a heated condition, it will burn with a violence proportionate to the temperature to which it has been previously heated; if this be near the exploding point, explosion must ensue, which will be violent in proportion to the strength of confinement of the material. A practical demonstration of this was furnished by an explosion which occurred at Woolwich in 1866. Several very strong packages (metal lined cases) filled with von Lenk's gun-cotton, some of which had been purposely left impure, had been exposed for seven months to artificial heat in a strong brickwork chamber heated by steam. The impure gun-cotton in some of the packages was then known to be in a decomposing state, but the experiment was continued, and eventually spontaneous ignition occurred, and at a time when the boxes were heated to the maximum temperature. The result was a violent explosion of all the packages; the very strong confinement, and the heated condition of the gun-cotton which ignited, added to its being at the time in a state of chemical activity, determined its explosion, and the explosion of the other packages was a necessary consequence of the violent concussion to which they were exposed.

There can be no doubt that the results of the recent experiments, and of those made last year, as also the results of the Stowmarket accident, have to be considered in relation to the *quantities* of gun-cotton operated upon, as well as to its confinement. The confinement of the

eight strong packages by the layers of boxes which surrounded them on all sides in the Woolwich experiment, was probably quite as great as that afforded by the light and roomy shed in which the *twenty-four* boxes of the same kind were placed in double layers in the South Coast experiments; yet in the latter case an explosion was developed, and not in the former with the smaller quantity. In the South Coast experiments, with 6 cwt. of gun-cotton, the explosions occurred eight seconds and ten seconds after the ignition of the gun-cotton; in the Stowmarket magazine, where several tons of gun-cotton were stored, the explosion appears to have *almost* immediately followed ignition; it must be borne in mind, however, that in this case much of the gun-cotton was very closely confined by the large number of surrounding packages, and that the temperature of the gun-cotton was already raised considerably throughout by long-continued very hot weather. Both of these circumstances must have greatly favoured the very rapid development of explosion, independently of the much more intense heat generated by the rapid spreading of fire through a large portion of the gun-cotton.

The satisfactory results obtained in the South Coast experiments with the lightly constructed boxes, with employment of 6 cwt. of material, appear to have received confirmation from the result of an accident which occurred in 1869 at Penrhyn, when a magazine of brickwork containing 20 cwt. of compressed gun-cotton, packed in boxes of light structure, was burned down without any explosion. But it is nevertheless very possible that a similar result would not be furnished by several tons of gun-cotton similarly packed; the much higher temperature which would be developed in that case by the first spreading of the fire, and the additional confinement, due to the larger number of packages, might combine to develop conditions favourable to the violent explosion of some portion of the mass; though, no doubt, a much larger proportion would burn non-explosively than if strong boxes were used. While, therefore, in storing *dry* gun-cotton the probability of violent explosions resulting from the accidental ignition of a magazine may be considerably diminished, or at any rate the violence of a possible explosion much reduced, by storing the material in packages of which some portions will yield readily to pressure from within, or by adopting any other storage arrangements (such as stacking upon lattice shelves) whereby the rapid penetration of flame or heat between the compressed masses is promoted, it must be considered as conclusively established by the last twelve months' experience, that such regulations as experience and prudence have rendered essential in connection with the storage of gunpowder and other explosive agents, must also apply to the storage of compressed gun-cotton when in the dry state.

Some results, which promise to have an important bearing upon the economical and efficient application of gun-cotton to naval and military purposes, have recently been obtained by the lecturer. It is well known that gun-cotton does not in itself contain sufficient oxygen to oxidise thoroughly the whole of the carbon in the substance, hence the full explosive force attainable through the agency of that carbon is not developed; moreover, the products of explosion of gun-cotton contain a proportion of the inflammable gas carbonic oxide, the production of

which may occasionally, in underground working, be attended by considerable inconvenience. The idea of furnishing the carbon with some additional oxygen, by *impregnating* the gun-cotton with saltpetre, or chlorate of potash, was entertained and worked out to some extent soon after the discovery of the substance, but the quantity of those oxidising agents which could thus be incorporated with the material was too small to produce any important practical results. The reduction of gun-cotton to a fine state of division by the pulping process, furnishes this substance in a condition in which it can readily be incorporated with any desired proportion of saltpetre, or of a chloraly, and the mixtures thus produced can readily be granulated, or converted into compact masses by compression.

Successful experiments with granulated gun-cotton thus produced were made several years ago in Mr. W. B. Beaumont's mines and quarries at Allenheads, and the granulated mixture was also used by Mr. Abel in 1868 as a vehicle for the employment of nitroglycerine, under the name of "glyoxiline."

"Nitrated" and "chlorated" gun-cotton in compressed masses, similar in form to ordinary compressed gun-cotton, have recently been made the subject of experiment at Woolwich, with satisfactory results. These compressed mixtures may be so manufactured as to produce equal, and in some instances superior, results to ordinary compressed gun-cotton at less cost; they are readily susceptible of detonation, and the fact that the gun-cotton particles are separated from each other by the interposition of salts which resist great heat without change, has been proved of decided importance in enabling them to withstand long-continued exposure to high temperatures. These compressed gun-cotton preparations are at present the subject of experiment by Government.

Gunpowder itself has not remained stationary during the development which has of late taken place in the application of violent explosive agents to naval and military purposes. In pursuing the investigation of the nature and causes of the phenomena exhibited by nitroglycerine and gun-cotton when submitted to the action of a detonation, Mr. Abel found that not only all explosive compounds, but also explosive mixtures, including gunpowder, are susceptible of violent explosion, even when quite unconfined, through the agency of a detonation, though the nature and violence of this detonation varies with different explosive substances. A sufficiently powerful detonating fuze will develop the violent explosion of gunpowder, when not closely confined, and this fact has already received useful application; thus, in submarine operations, it has been decisively established that the employment of detonating fuzes dispenses with the necessity for confining a gunpowder charge in a very strong receptacle. Other interesting results have recently been obtained with gunpowder, which have, however, a more exclusive bearing upon its industrial applications.

Evening Meeting.

Monday, June 17th, 1872.

Lieutenant-General the Right Hon. LORD SANDHURST, G.C.B., G.C.S.I., in the Chair.

NAMES of MEMBERS who joined the Institution between the 28th May and the 17th June, 1872.

LIFE.

Lowndes, James, Major Renfrew Militia.
Fairfax, Henry, Captain R.N.
Geddes, A. D., Captain 27th Regiment.
Martineau, Geo., Lieut. 6th Surrey Rifle Volunteers.
Rigby, Walter A., Major 1st Lancashire Engineer Volunteers.
Wilson, W. T., Lieut. Royal Engineers.
Darwin, Leonard, Lieutenant Royal Engineers.

ANNUAL.

Bax, W. J., Capt. 11th Bengal Cavalry.
Mawson, W. Wilmott, Lt.-Colonel 33rd Lanc. Rifle Volunteers.
Franklyn, E. J., M.D., F.R.C.S., Surg.-Major R.H.A.
Tandy, Dashwood G., Commander R.N.
Borthwick, Alexander, Capt. Rifl. Brig.
Dickins, A. D., Lt.-Col. Beng. Staff Corps.
Gisford, Horace C., Lt. Gren. Guards.
Irvine, M. B., C.M.G., Asst. Controller.
Tytler, J. M. B. Fraser, C.B., Maj.-Gen.
Jary, Robt. H., Mj. late 12th Roy. Lancers.
Lloyd, T. H., Lt. Royal Horse Artillery.
Ballantine, R. F., Lt. 1st W. India Reg.
Goldsworthy, J. W., Lieut. 86th Regt.
Smith, Edwd. Leadbitter, Capt. North Durham Militia.
Pringle, Charles, Captain R.N.
Browne, C. Orde, Captain late R.A.
Clarke, W. A., Capt. North Durham Mil.
Hillyard, G. A., Lieut. Rifle Brigade.
Austin, G. L., Capt. Rifle Brigade.

MILITARY TRANSPORT AND SUPPLY IN INDIA.

By Lieutenant E. H. H. Collen, R.A., Staff College, Sandhurst.

When I accepted the honour of an invitation from the Council of this Institution to read a paper on Military Transport and Supply in India, I did so with considerable reluctance. Beyond the fact that I shoud be addressing Officers whose experience has been so much greater than mine, I felt that the subject was almost too large and intricate to be dealt with by me. Further than this, the time left at my own disposal was extremely limited, and I felt that it would be no light task to compress the vast array of facts and principles into one paper.

At the outset we must start with the recollection that the military machine in India has to be worked for an Army of 180,000 British and native soldiers, scattered among more than 180 military stations and posts, guarding an area of nearly 1,000,000 square miles and peopled by more than 150,000,000 of human beings. This statement is in a certain degree a measure of the difficulties of military administration in India; and, bearing this in mind, I shall ask you to glance rapidly at the main features of that administration, in order that we may clearly understand the points of analogy or difference between the Indian and English systems of supply and transport.

I need hardly remind you that the great empire of British India is divided into several local administrations, at the head of which are

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Governors, Lieutenant-Governors, or Chief Commissioners. The chief of these administrations are Bengal, Madras, Bombay, the North-West Provinces, and the Punjab; presided over by Governors or Lieutenant-Governors: and descending in the scale of importance, Burmah, the Central Provinces, Oudh, and Sindh; these latter provinces being administered by Chief Commissioners. For military purposes, however, India may be considered to be divided into three great sections, viz., Bengal, Madras, and Bombay; but under the term Bengal we must place the vast area comprised by Bengal, the North-West Provinces, the Central Provinces, Oudh, and the Punjab; under Madras, Burmah; and under Bombay, the province or district of Sindh.

The Governor-General in Council is the head of all civil and military power. His government is supreme over all the administrations I have just enumerated. The Commander-in-Chief in India is the executive military authority and military adviser of the Government of India, while he also fulfils the duties of local Commander-in-Chief in Bengal. But while stating this, we must remember that the Presidencies of Madras and Bombay, although under the Supreme Government, maintain an independent position in that they are in direct communication with the Secretary of State for India, and that each of these administrations has a local Commander-in-Chief and a Council. In the same manner, therefore, we find in Madras and Bombay distinct Armies and Army Departments, whose administration is to a great extent independent of the Governor-General and the Commander-in-Chief in India.

Returning to the Supreme Government of India, in its military aspect, the Military Member of the Council of the Governor-General is the War Minister of India. Under his especial charge is the Military Secretariat of the Government of India; and, putting aside the fact that the Secretaries are military men, we may look upon this Secretariat as the War Office. This Secretariat comprises an account branch, under the Controller-General of Military Expenditure, who may be compared to the Accountant-General in England. It is the duty of the Controller-General to review all military estimates before final submission to the Financial Department, *i.e.*, the Treasury, and to give the benefit of his advice upon the financial bearing of military questions.

The Military Department of the Government of India, as it is termed in India, which would be known in England under the title of War Department, consists therefore of the Governor-General, his Council (which includes the Commander-in-Chief), and the Military Secretariat, the latter being the agents by which the orders of the Governor-General or that of his delegate, the Military Member of Council, are carried out to the Executive Military power, or to the so-called Civil Departments of the Army. Under this head we have 1st, the Military Account Department; 2nd, the Commissariat; 3rd, the Ordnance, or, as it is officially termed, the Ordnance Commissariat Department; besides the Barrack Department, which is now a branch of the Public Works Department, and the departments known as Stud, Clothing, Medical, Education, &c. I may recall to your minds the

fact, which I have before stated, that these Army Departments in Madras and Bombay, are only in a general way under the Government of India, while they are specially under the separate Military Department of their own Government.

In considering the analogy between the Officers of the Control Department in England, and of the Pay and Supply Departments in India, it appears to me that the Officers of the Pay Sub-department of the Control are represented in India by the subordinate Officers of the Pay and Military Account Departments, whose chief in each Presidency is termed the *Controller of Military Accounts*, and this latter functionary would seem to bear also the financial responsibility, which is exercised by the Controllers in the Home Service. The Commissaries of the Supply Transport Branches of the Control Department would be represented in India by the Officers of the Commissariat Department, and by the Commissaries of Ordnance of the Ordnance Department, while the Officers of the Indian Departments also exercise, each in his own sphere, the higher functions of the Controllers in England.

I purpose this evening to try and present to you the salient features of this great subject: first, considering the Departments of Supply, and then describing the system of Transport.

Speaking generally, and without considering the distinctions of Presidencies, there exist two great Supply Departments: the one, the Commissariat, charged with the supply of provisions, forage (in certain cases), fuel, light, bedding, hospital clothing and requisites. The other, the Ordnance Department, charged with the custody and supply of all warlike and military stores necessary for an Army, and all raw materials used in making or repairing these. In addition, we have the Clothing Establishment and Medical Store Depôts in each Presidency. But upon these I shall not touch, because the former is not a separate department, but only a manufactory, while the latter is under the Medical Department.

I shall treat of the Commissariat under three heads:—

$$\text{Commissariat}\begin{cases}a.\ \text{Personnel and Administration.}\\ b.\ \text{Execution.}\\ c.\ \text{Account.}\end{cases}$$

a. Personnel and Administration.

At the head of the Commissariat Department of each Presidency there is a Commissary-General responsible to Government for the administration of his department, and subordinate to him, Deputy, Assistant, Deputy-Assistant, and Sub-Assistant Commissary-Generals.

In addition to these Commissioned ranks, there are Warrant Officers, Deputy, Assistant, and Deputy-Assistant Commissaries, Conductors, and Sub-conductors, with a further class of Non-commissioned Officers or Sergeants.

The whole of these Officers are drawn from the British or Indian Army, and the total number for all India is 101 Commissioned, and 103 Warrant Officers. All Officers of the British Army are required to enter the Indian Staff Corps, and, with the exception of the Commissary-General, who may be selected from the Army at large, every

Officer must enter at the bottom of the junior grade, while, however, his military promotion goes on in the Staff Corps.

It is a necessary condition of appointment, that an Officer shall have passed the "Higher Standard" examination in the native languages, or corresponding examination, and a preliminary examination. The Officer is then sent for six months to one of the chief commissariat charges to learn the executive duties of the department; after this he joins the office of the Examiner of Commissariat Accounts for three months, and he is then sent to the Head Commissariat Office of the Presidency, where he works under the supervision of the superior Officers of the Commissariat Department.

At the expiration of this year of probation he has to undergo a final examination. This examination embraces many subjects, and I shall venture to allude to them in detail, because it indicates the nature of Commissariat duties in India.

The examination-subjects may be classed under the following heads: —The care and custody of cattle and commissariat stores; the system of procuring supplies by departmental agency or by contract; the mode of rationing British and native troops; departmental rules and returns; the drawing up of estimates and average statements of the cost of victualling troops and feeding cattle; the equipments of cattle, and commissariat stores required for cavalry, artillery, and infantry on the march; cattle for food or transport, breeding, weight, &c.; reading he accounts of native subordinates, in writing orders and letters in the vernacular, and in knowledge of Commissariat Accounts.

The Warrant Officers are appointed from the non-commissioned grade, and these last from the Army. The subordinate establishment consists of native clerks, agents of different grades, workmen, and labourers, fulfilling the multifarious executive duties required of the Indian Commissariat in peace or in war.

The Bengal Presidency is divided into three circles of commissariat superintendence, each presided over by a Deputy Commissary-General, but this division is not carried out in Madras and Bombay.

At each military station in India where British troops are to be found there is a Commissariat Officer, whose rank is dependent upon the extent of what is called the Executive Commissariat Charge. The duties of an Indian Commissariat Officer are various and responsible, for these duties of supply extend over large areas of country; he has to search out the resources of the land; to ascertain what amount of cattle he may demand from the country for provisions or for transport: to enlist the natives in his work; to supervise the reception and care of the materials for provisioning the Army, and their distribution. On the one hand he must maintain intimate and cordial relations with the commanding Officer of the station, and of the larger units of command; on the other he is responsible to the chief of his department, and hence to the Government of India, for the proper carrying out of the principles and rules laid down for his guidance. On the one hand he is enjoined to act in conformity with the wishes of commanding Officers; on the other, should orders be received which are contradictory to the directions of the Commissary-General, the Com-

missariat Officer must, if personal explanation fail, obey the order, and report the matter to his chief; so that while he is not absolutely a military staff Officer, he subordinates himself, even if senior in military rank himself, to the commanding Officer of the station, acting in accordance with his wishes, while he has also to preserve his departmental relation to the head of his own department.

We now come to the second section, under the heading Commissariat,

b. Execution.

There are two methods of supply in India, apart from the stores furnished from England, viz., 1st direct agency, 2nd contract. Direct agency is now wholly employed in the Bengal Presidency for meat and bread, the latter being made by the Commissariat bakeries. When the contract system is employed, contracts are for one year, and for stations only.

The soldier's ration is, as you know, given free in India, but time does not permit me to do more than mention that the whole subject of the rationing of British troops is so fenced round by regulations and the power of the regimental authorities, that it is very difficult for bad rations or liquor to be issued, and impossible for them to be consumed; while the Commissariat authorities are careful to affirm that the absence of complaints or rejections on the part of the troops will be regarded as tacit proof of good executive management.

The means by which native troops are supplied forms a peculiar feature of the Indian system. As a rule, the Commissariat does not supply rations to native troops, except in localities where food is impossible to obtain by other means; but Government provides for the varying dearness of provisions in different parts of India, by granting compensation whenever the price exceeds that which is laid down for a certain scale of rations. With native troops the bazaar is the supplying agent; this bazaar is a kind of permanent market of native sellers, who make it their business to supply troops with provisions and other requisites. The bazaar is under the control of the military authorities, being under the especial charge of the quartermaster of the regiment. Strict rules are laid down with regard both to the quality of the provisions sold to the troops, and the sanitary and police arrangements of the bazaar.

This method of supply is convenient for the natives, and adapted to the country. It encourages self-dependence; directly enlists the love of gain of the inhabitants of India, and gives them a permanent interest in the supply of the troops for all operations within the confines of our territory; while the superintendence of regimental and medical Officers ensures the just treatment of the supplying agents, and provides for the good quality of the food.

But this system has its disadvantages. It is, as a rule, inoperative in war carried on beyond our frontier; and while the native soldier is ready enough to take his pay, and the allowance granted to him in compensation for the dearness of provisions, he is not always ready to purchase food sufficient for health.

The supply of provisions to hospitals is made by the Commissariat

Department through a hospital purveyor who, although a native subordinate, entertained and paid by the Commissariat, acts under the orders of the medical officer.

Forage in India is supplied by the Commissariat in respect to grain, while the grass is ordinarily procured by grass-cutters belonging to the regimental establishment of mounted corps. In the native cavalry, however, the troopers supply their own forage, receiving extra pay for this service.

Fuel and light are supplied by the Commissariat.

The next division of our subject under the section *b*, *Execution*, may be placed under the heading *Stores*.

Previous to 1861 the Commissariat acted as the purchasing agent for all departments. The evils of this system consisted in the fact that the Commissariat Department had no power to control or reduce expenditure, while a further difficulty was prominent in the labour thrown on the Commissariat. Nor was there any great advantage to compensate for its defects, while it pointed to the principle that a purchasing department ignorant of the exact and ultimate use to which the stores would be put, must necessarily be inferior to the agency of the department actually requiring and using them. Accordingly, Government determined that each department was to be responsible for its own expenditure, and that this expenditure was to be separately exhibited in accounts.

The Commissariat Department supplies all *bedding* and *hospital clothing*.

To give any idea of the number of items which come under the head of Miscellaneous Commissariat stores, would be quite impossible, but we may recollect how various are the requirements of the soldier in India, and that in excess of his wants in England, we must add those necessitated by the climate and peculiar nature of the service. We may, then, before quitting this section of the subject, say, that the Commissariat Department supplies all stores, excepting those which are strictly ordnance, medical, clothing stores, or barrack furniture.

The third section under the heading Commissariat, is that of—

c. Account.

The Commissariat Department in India is not an account department in the strict sense of the word. Every executive Commissariat Officer keeps an " account current," examines the accounts of native agents, forwarding these with the necessary bills and vouchers to the Examiner of Commissariat accounts. This functionary, although he may have been a Commissariat Officer, is not an official of the Commissariat Department, but is under the Controller of military accounts, the chief of the Pay and Military Account Department.

Estimates are prepared by executive officers, collected in the Commissary General's office, and forwarded to Government through the Controller of Military Accounts.

Commissariat charges are divided under two heads:—

I. Commissariat expenditure proper.

II. Expenditure on behalf of other departments.

This second class the Commissariat Examiner audits as well as the first, but debits to the department concerned.

The Commissariat, however, pays one class of charges, viz., all those connected with transport, whatever department those charges may belong to, the amount being ultimately debited to that department. Speaking broadly, the Examiner's functions are to see that moneys and stores are appropriated by executive officers according to orders, and he in fact is the first auditing authority, without the Commissariat Department.

A broad distinction is drawn between financial and Administrative control, and while the Examiner is permitted to make all enquiries necessary for his purposes, he is required to abstain from interference in the administration of the Commissariat Department.

I shall now pass on to describe the constitution and functions of the Ordnance Department, treating this portion of the subject under three sections, viz.:

Ordnance { *a.* Personnel and Administration.
b. Execution.
c. Account.

a. Personnel and Administration.

Setting aside Presidential distinctions, we may say that the Ordnance Department has charge of all warlike and military stores. Besides all purely artillery stores, and those for the park and siege trains, it takes charge of all small arms and materials for their repair, tools, engineer stores, harness, saddlery, accoutrements, camp equipage, and in fact all the equipments and military stores required for an army. In addition, it has charge of all kinds of raw material required for military purposes.

In each Presidency of India there is a distinct Ordnance Department, with an Inspector-General of Ordnance at the head of each. He is the administering chief and the adviser of Government, and the Commander-in-Chief on all questions of war *matériel.* This functionary has a similar position to that of the Commissary-General, and unless on inspection duties, resides at the seat of Government and Army headquarters. Subordinate to him, are the Deputy Inspector-General and the Commissaries of Ordnance, the latter of whom are graded in three classes, being 26 in number for all India. Again, subordinate to these are warrant officers, styled deputy, assistant, and deputy-assistant commissaries, conductors and sub-conductors, to the number of 198 for the whole of India. Further, there is the Non-Commissioned class or Sergeants. The remaining portion of the Ordnance Department personnel, consists of clerks, artificers, and labourers.

The Commissioned Officers or Commissaries of Ordnance are drawn exclusively from the Artillery. They must have had five years' service, and have passed the examination in the native languages. They are usually selected to fill vacancies caused by Officers proceeding on

furlough, and on joining the Department remain "officiating" or "acting" for some time, and they have then to pass an examination in technical knowledge and the conduct of the business of an arsenal. The permanent appointments are now held for five years, during which time the Officer is "seconded" in the regiment.

The Warrant Officers are promoted from the non-commissioned rank, this last class being recruited from all branches of the service, the Inspector-General, through his subordinate Officers, deciding on the merits of the candidates by examination. Those selected are attached to an arsenal, instructed in their work, and if found qualified are permanently appointed. The Deputy Inspector-General of Ordnance is at the head of the Ordnance Office of each Presidency. He administrates the interior economy of the Department, and generally supervises the check and passing of all requisitions for stores, a Commissioned Officer being appointed as his assistant in these duties.

Although perhaps belonging to the next section, viz., *b*, *Execution*, it may be as well to consider in this place the meaning of the terms Arsenal, Magazine, and Depôt, as applied to India. In India an arsenal is an establishment for store and construction; a magazine is a similar establishment of a less important character, especially as regards workshops; while a depôt is merely a place for the store of those articles which are most required by the troops.

The duties of Commissaries of Ordnance in charge of an arsenal are very heavy and responsible. In time of peace all requisitions or "indents" not of an emergent nature are sent by corps or departments through the Ordnance Office of each Presidency. These "indents" are checked by the Deputy Inspector-General, and supply ordered upon the proper arsenal or magazine. It then becomes the duty of the Commissary of Ordnance to carry out this order as expeditiously as possible, either from his stock or by manufacture. He has perpetually to supervise the receipt and issue of stores, to watch and inspect manufacture, to conduct experiments and proofs, to visit in their turn the various establishments under his orders, to conduct the large correspondence of his office, and to overlook and guide the administration of the arsenal. In addition to this, the armaments of forts are in many cases in his charge, although, I am happy to say, these are being gradually placed in the hands of their natural guardians, the Royal Artillery. The Commissary of Ordnance is not a Staff Officer of the General, nor are the stores in arsenals or magazines directly under the military authorities. On the other hand, the Commander-in-Chief, the Generals of Division, Officers commanding stations, as well as the Officers commanding Royal Artillery districts or divisions, have power and are required to inspect the ordnance establishments in their command, and to bring to notice any defects which they may observe.

The next section of my subject under the heading *Ordnance* is—

b. Execution.

In each Presidency of India there are ordnance factories which,

although not absolutely belonging to the Ordnance Department, are directly under the Inspector-General of Ordnance, and are in charge of Artillery Officers. Besides these powder factories, the one gun factory, and carriage factories, there are small arms' factories, in charge of selected Commissaries of Ordnance; and in Bengal a harness and accoutrement factory, also in charge of an Ordnance Officer.

Within the last few years, the Government of India determined to carry out the principle that it is advantageous both in a military and financial point of view to maintain good and sufficient arsenals at strategic points than to multiply these bases of supply, thus multiplying danger points necessary to be defended. Accordingly this has been carried out in the Bengal Presidency, in which there are now 3 arsenals, 2 magazines, and 5 depôts, while in Madras there are 2 arsenals, 3 magazines, and 6 or 7 depôts, and in Bombay 2 arsenals, 5 magazines, and 1 depôt, making a total for India of 7 arsenals, 10 magazines, and 12 or 13 depôts.

I shall not try your attention by doing more than mention that an Indian arsenal is divided into stores, or "godowns," and departments of work. Then we have the Issue and Receipt Departments, pattern or "muster" rooms, armouries and armoury workshops, harness and saddlery stores, accoutrement stores, foundry, tool, tent, raw material, and unserviceable stores, the Park, containing the siege trains and artillery heavy materiel, laboratory, and magazines, and workshops. As a rule each of these departments is in charge of a Warrant Officer, in the case of the stores as Storeholder, assisted by a non-commissioned Officer, if necessary, and a native accountant. These Warrant Officers are placed in charge of the various departments by the Commissary of Ordnance according to the branch of the service from which they came and their peculiar fitness for the post.

Stores are obtained from England through the India Office and the India Store Department. They are also manufactured in the Ordnance factories and the workshops, obtained by local purchase, contract, or occasionally from other Departments. As I have stated before, "indents" or "requisitions" for stores ordinarily pass through the hands of the Deputy Inspector-General. If, however, an "emergent" indent is countersigned by Officers commanding divisions, brigades, sections, or detachments, the Commissary of Ordnance is bound to comply with the order, although in the case of the supply being unauthorised, he is equally bound to point out the regulations on that head.

We now come to the third section, viz., c. *Account.*

An arsenal or ordnance establishment is not, strictly speaking, an Account Department. The Office Establishment keeps the store ledgers, collects the returns, accounts, and vouchers. The returns of receipts and issues, with vouchers, accounts of sales of unserviceable stores, contingent bills for extra expenditure, returns of expenditure of labour and materials, are merely compiled and forwarded to the Examiner of Ordnance Accounts, who is an Officer of the Pay and Account Department, under the Controller of Military Accounts,

although he may have been an Ordnance Officer, and by this official, the first financial audit is made.

We must now proceed to consider generally the system of transport employed in India. I have divided this under two heads, viz.,

A. *The existing train*, or that which is permanently kept up;

B. *The auxiliary train*, or that which consists entirely of hired animals and vehicles.

A. *Existing Train.*

The general system is under the Commissariat Department, the agent for procuring all transport.

In the first place we must start with the knowledge that no organisation exists in India corresponding to the transport branch of the Army Service Corps.

The first great feature of the Indian system is that at certain important stations transport for "moveable columns" is kept up, so that these columns, which are under the Commanding Officer at the stations, may be ready to move at short notice to repress any disturbance, and to take command of the country. And here I may remark that the existing train is composed of carts drawn by bullocks, pack bullocks, elephants, camels, and mules. The drivers and attendants of this train are Commissariat followers, subject to the native articles of war, although not enlisted soldiers, while the controlling authority consists of European and native Commissariat subordinates, supervised by the Officers of the Commissariat Department.

The present scale of "moveable columns" was fixed in 1861, and for Bengal may be taken, as constituting a force of—

9 batteries, or 54 guns, with the first line of waggons only.
6 squadrons British cavalry.
9 ,, Native ,,
9 battalions British infantry.
12 ,, Native ,,

The Madras and Bombay transport is, I believe, kept up for about one-third of the amount required for the Bengal Presidency, but I have been unable to obtain any details regarding these Presidencies.

Generally speaking, the column may be called a small brigade of all arms, although at places where native troops alone are stationed it may consist only of native cavalry or infantry.

The largest column in Bengal consists of—

1 battery of artillery.
1 regiment of British infantry.
1½ ,, Native ,,
1 ,, ,, cavalry.

And the smallest of all arms of—

½ battery of artillery.
wing of a British infantry regiment.
,, Native ,,
1 squadron of Native cavalry.

In Bengal there are 23 "moveable columns," and if we estimate those in Madras and Bombay together at one-third of the Bengal strength, we should have approximately a force of—

12 batteries.
8 squadrons British cavalry.
12 " Native "
12 battalions British infantry.
16 " Native "

Or, in other words, transport provided for a force equal to an army corps of 72 guns, 28 battalions of infantry, and 20 squadrons of cavalry.

The carriage for these moveable columns is maintained at a scale which would enable the column to move out, carrying for the British portion of the force all the numerous requisites of camp life on field service in India.

1. Camp equipage, using the large marquees for soldiers in India.
2. Baggage, at 720 lbs. per Officer, including mess, and men at 50 lbs.
3. Cooking utensils, at 50 lbs. per troop or company.
4. Ammunition, at 120 rounds per British infantry soldier.
5. Rations for seven days.
6. Rum for seven days.
7. Commissariat stores.
8. Rations for natives for two days.
9. Quartermaster's native establishment.
10. Medical and hospital stores.

Besides the conveyance of sick, which I shall speak of under the head of medical transport. It will thus be seen how liberal is the scale allowed, and if we consider that operations might have to be undertaken in the hot weather, perhaps not unnecessarily so, but this is a point to which I shall presently draw your attention.

It would be impossible for me in this short paper, and wearisome to you, to go through the different scales of carriage for the British and Native corps of these moveable columns, and it will be sufficient for me to mention that for mounted corps, while subtracting some of the items I have mentioned above, we must add others, as veterinary stores, scales and weights, bullock gear, and grain, or grain for horses for two days.

For native cavalry and infantry the scale of transport is much less than for British soldiers, as the tents used by natives are much smaller, and the baggage is altogether on a reduced scale.

It will, however, give some idea of the extent of transport necessary in India if I state that a regiment of British infantry equipped on this "moveable column" scale requires about—

41 elephants and 280 camels.

A battery of artillery—

10 elephants and 74 camels.

A squadron of British cavalry—

7 or 8 elephants and 66 camels.

A regiment of Native infantry—
112 camels.

And a squadron of Native cavalry—
9 camels.

This amount I may state includes medical stores, although not medical transport for the sick.

In the Bengal Presidency the authorised transport establishment is, speaking approximately—

1,000 elephants.
6,600 camels.
350 pack bullocks.
530 draught bullocks.
1,500 mules.

Medical Transport may be divided into—

1. Ambulances.
2. Doolies or litters.

With regard to the first, two per regiment is the establishment, but these vehicles are much rougher in construction than those used at home.

The second kind of transport, doolies or litters, is well known, and needs no description from me. In cantonments two doolies are allowed to each regiment of cavalry and infantry, and one to each battery of artillery. It is laid down that half the sick carriage for British troops is to consist of ambulances, and half of doolies. For British troops the scale is for 5 per cent. of sick on ordinary, and 10 per cent. on active service, and for native troops 2 per regiment of cavalry or infantry on ordinary service, and 6 or 8 on active service.

Medical transport is kept up allowing 5 per cent of the strength of moveable columns. The bearers of the doolies for these moveable columns—and we may remember that about 245 are required per British regiment—are employed during the hot weather in pulling punkahs, and other duties connected with barracks. In the cold weather these men, and in fact all the carriage of the moveable columns, are made available, if required, for carrying out the relief of the troops, while generally the commissariat carts and cattle, kept up as permanent transport, are used in the garrison duties of cantonments.

Reserves of bullocks and mules are kept up at various stations.

The next section under the heading A, existing train, is that of *Siege Train or Ordnance Transport.*

At certain strategic points in India siege trains are maintained, and for these large sized bullocks are required and kept up. The equipment is in charge of the Ordnance Department, but the bullocks themselves are under the care of the Commissariat, and, except a few employed on ordnance duties, are used by the Commissariat Department.

For the siege trains in Bengal about 5,000 or 6,000 bullocks would be required, and I think about one-third of that number are maintained as a nucleus of transport.

The *Special Transport* maintained in India is that belonging to the Punjab Frontier Force. This force, consisting of 6 batteries, 5 regiments of cavalry, and 11 regiments of infantry, all native troops, has attached to each corps a certain number of camels and mules, from 30 to 40 of each class, so that it may be enabled to take the field lightly equipped at an hour's notice.

B. *Auxiliary Train.*

The *Auxiliary Train*, which is the second general heading under the subject *Transport*, may consist of hired animals, vehicles, and drivers. These are obtained by the Commissariat through the agency of the civil authorities; and the rules for the payment, care, and treatment of this carriage, which is in a certain way "requisitioned" by the civil power, are very various and strict, differing moreover in different provinces. Before leaving this section of the subject, I may mention that in Bengal the camels even of the existing or permanent train, are hired under what is termed the "Chowdry" system; these "chowdries" being commissariat servants or agents bound to supply the necessary number of camels and camel-drivers. The camels and drivers, although hired, are practically in permanent employ, as they may be collected for inspection at uncertain times, or for employment. There are also hired for the permanent use of the Commissariat Department in Bengal, about 2,000 pack and draught bullocks, and 400 mules.

Railway Transport is provided on the authority of the Officers of the Quartermaster-General's Department; and upon this head I need only remark that the number of carriages required in India for the various arms is greatly in excess of the number necessary in Europe.

Sea Transport is taken up by a board of Staff and Medical Marine Department Officers, the vessels being provisioned by the Commissariat.

Inland Water Transport.—Steamers and flats are usually provided by the authorities of the Marine Department existing at the ports, while boats are procured by the Commissariat Department.

The limit of this paper does not permit me to do more than briefly allude to the action of the Indian Departments of Supply and of Transport in warlike operations.

In time of war, Commissariat and Ordnance Officers become practically the Staff Officers of the General in command, and take their orders from his Staff.

In expeditions beyond our frontier there is practically only one system of supply, that of magazines (using the term in its English signification), unless it be in expeditions of such short duration that the provisions are carried with the troops.

In the Huzara Expedition in 1868, the troops, consisting of two brigades, carried in their haversacks one day's rations, while the Commissariat supplied British troops with biscuits or flour, tea, and vegetables for seven days; the native troops and followers being provisioned on a similar scale. The Force was absent 17 days instead of 7, but the Establishment of Supply-Depôts and the exertions of the Commissariat prevented any scarcity of food being felt.

I shall not enter into the operations of these Departments in the Abyssinian Campaign, as the exhaustive official record of that Expedition gives every particular regarding the supply and transport over a line of communication nearly 400 miles from the base of operations.

In the Lushai Expedition, which has only lately terminated, the two columns advanced through dense jungles, over ranges of mountains from five to six thousand feet in height, and their lines of communication were maintained for four months over a distance of about 200 miles from the primary base of operations; secondary bases and intermediate magazines being established on this long line.

I believe it was intended that the troops should carry two days' food in haversacks, eight days' food on transport animals, and that there should be 14 or 15 days' supply at the nearest advance depôt or magazine, and a supply for four or five months at the base of operations. This, I presume, would very nearly be what was actually done, although I have been unable to obtain any precise information.

In the Camp of Exercise at Delhi, the troops manœuvring consisted of three Divisions, each Division being composed of a cavalry brigade and two brigades of infantry, each brigade including a battery of horse or field artillery; and for this Force 120 elephants, 1,800 moveable column camels, 600 hired camels, 400 bullocks were used in transport operations. Depôts or magazines had to be formed at convenient points, and I believe the Commander-in-Chief declared that the Commissariat Department proved itself equal to every occasion, both as regards supply and transport.

The transport in India during war, or expeditions beyond our frontier, is told off to corps and batteries for regimental requirements; special transport by coolies being sometimes organised. The Medical authorities are in charge of the transport for the sick; the Ordnance officers in charge of that required by the field arsenals and siege trains; while the Commissariat exercises general supervision over its cattle and subordinates attached to corps and departments, as well as over that especially working for the Commissariat service. This is not, therefore, a complete fulfilment of the regimental system, although approximating to it. The only real system is to give each corps its own transport, limited to a minimum; and to make that corps responsible for its efficiency. The objection urged against this is, that when the force is halted, a large amount of transport is locked up; but I would meet this by saying, that it must always be perfectly in the power of the General and his Staff to use regimental transport in any manner he may desire.

In Abyssinia the artillery of the Bengal brigade had its own transport. The consequence was, that it proved eminently useful for general as well as special duties, and the baggage mules were equally cared for with the gun and ammunition mules.

In India, on active service, the first reserve of small-arm ammunition is carried on camels or mules, according to the nature of the service; and the remaining reserves by the Ordnance Department or Field Arsenal. The gun-ammunition, beyond that in the first line of waggons, is carried in the second line of waggons, for which, however,

bullocks are not now kept up in time of peace, although reserves provide to a certain extent for emergencies. The remaining reserve gun ammunition is in charge of the Ordnance Department.

Before leaving this section of the subject, I would call your attention to the fact that the system of *etappen* organisation, now so familiarised to us, has long been exemplified in Indian operations, and in the maintenance of the lines of communication with the base.

I fear that I have already trespassed too long on your patience, but I will ask you to allow me to pass in review certain points, without which my attempt to describe the Indian system would be still more incomplete than it is.

The evidence of the operations during the Mutiny, and of the expeditions which have taken place since that time, stands out as proof of the executive and administrative ability of Indian Commissariat Officers in war as well as in peace. The administration of the Commissariat Department is left entirely to the Commissary-General, through whom all propositions for change in interior economy are submitted to Government. The duties of an Indian Commissariat Officer are varied, and, I believe, educate him to that responsibility which he is frequently called upon to take. If I may be permitted to name the defects, I should say that, in common with all administrations and armies ruled by a central authority, there is too great a tendency to over-regulations and the multiplication of returns. Nor is this evil productive of only extra work. The current work in Indian Departments is so great, that reforms are difficult to effect by the heads of departments, who should be the officials to initiate and carry them out.

In the *Ordnance Department* we may say that it would be desirable to appoint to it Officers who had passed through scientific courses in England; and that there is great difficulty in India in obtaining scientific information. It must be remembered, however, how great has been the trial of the Indian Ordnance Departments during and subsequent to the Mutiny. The changes in organisation and in *matériel* have been very great. Large accumulations of old stores have had to be used up, and naturally enough Officers coming from England, ignorant of this fact, dislike to use these old pattern equipments. Commissaries of Ordnance soon acquire a knowledge of those stores which are not peculiar to their own service, and the choice of subordinates from all branches of the Service gives a good field of selection for the various classes of work.

In speaking of *transport*, we must all agree in the necessity for an efficient system of this moving principle of military administration. But the fact that it is financially impossible to keep up a gigantic transport train in time of peace, must go hand-in-hand with the first statement. It is an accepted military axiom, that we must have the nucleus and framework in time of peace, which in time of war may admit of expansion. It appears to me, though I feel I ought to submit the opinion with great deference, that in the Indian Commissariat Department resides the natural framework of an Indian transport system.

The officers of that Department are trained to a knowledge of cattle

of all kinds. They are brought into daily intercourse with natives who must always form the main bulk of the *personnel* of Indian transport; they are acquainted with all the various gear and equipments required in transport. Their department is that which involves the greatest use of transport in time of peace; in a word, their duties in peace contribute to their efficiency in war.

But, having said so much, I should be far from wishing you to believe that the present Indian transport system admitted of no improvement. In the first place, the "moveable columns" require the frequent exercise which is insisted upon in a letter from the Secretary to the Government of India to the Adjutant-General, and which is published at p. 166 of the evidence before Lord Strathnairn's Committee, Report on Supply and Transport. To use the words of that letter, these columns "should be exercised so as to enable Commanding Officers and others to become personally acquainted with the actual requirements of moveable columns, and so that in times of tranquillity these columns may become so accustomed to move that, when required to turn out under the sudden call of duty to quell any disturbance, every one may know his place and clearly comprehend what he has to do, so that confusion and disorder may thereby be avoided."

The want of a more military organisation in Indian transport trains has formed the theme upon which successive Commanders-in-Chief have enlarged; and in Napier's "Administration of Scinde" will be found a vivid and picturesque account of the difficulties of marching with the huge and comparatively untrained "impedimenta" of Indian forces.

But although the difficulty is to a great extent financial, I believe that it might be overcome by giving the present transport a somewhat more military character, but distinctly retaining it under the Commissariat Department. An experiment might be locally tried in establishing a regimental system of transport for very light field equipment, by supplying materials for carts from the old stores of the Ordnance Department, and employing those bullocks which are used by a regiment in cantonments. Regimental Officers and men might be encouraged to qualify themselves in supply and transport duties, with the knowledge that they would probably be selected to fill in the framework of supply and transport when an expedition or war necessitated a sudden expansion of the nucleus possessed by the Commissariat Department. Under the present system it is an undoubted evil that Officers and men are often selected who are not previously trained to these important duties.

The expeditions of Huzara and Lushai have taught us how British and native troops can march and fight, without tents and with baggage restricted to an absolute minimum. While, therefore, we may agree that the scale of the "moveable column" baggage is somewhat excessive, according to our later experiences, we must remember that it would be madness to attempt to take the field in the hot weather in India without the shelter and requisites which are not military necessities in a good climate.

The triple nature of the Indian Departments is a patent evil, but this is too great a subject to be entered upon here. On the other side, the supply administration of India, if we set aside Presidential distinctions, seems to possess many advantages of simplicity, in that all *munitions de guerre* are under the Ordnance Department, and all *munitions de bouche* under the Commissariat.

Before releasing you from your kind attention to this lengthy paper, I desire to state that time did not permit me to obtain information from India on several points connected with this subject, nor have I been able to correct up to date certain minor details of Indian Transport by official information. I have, however, to express my acknowledgments to Sir Thomas Pears for having permitted me to look over general orders, &c., which have been published since I left India; and I must further thank Col. Dickens, C.B., who was Chief Commissariat Officer in the Huzara Expedition and at the late Camp of Exercise at Delhi, and also Major Colley, Professor of Military Administration at the Staff College; for several valuable suggestions.

In conclusion, I think we must all agree in the necessity for the study of military administration by Officers of the Army. Indian experience seems to point to the conclusion that if military men be properly trained they are equally capable of dealing with finance and supply as are civilians, and equally careful of the interests of the State. Whether the so-called civil administration of the Army is governed by civilians or by military men, we must all unite in believing that ignorance of Officers of the Army in matters of finance and supply leads to incessant friction between the Army and its departments. We, who belong to what is sometimes termed the combatant branch of the Army, are too apt to throw aside ideas of finance. The Army consequently divides itself into two great parties; the so-called combatant branch looking upon the supply departments as some mysterious and sinister element in Army administration, constantly thwarting the former's just ideas of efficiency, while the so-called civil administration looks on military men proper as a class constituted to be checked and controlled, and always desiring more than they are entitled to.

I think we soldiers should think more of the State, though not less of the Army; that we should try and understand that departments of supply are bound and financially sub-divided by estimates; that Government is not an inexhaustible purse-holder, only intent upon miserly economies; and that while those acts of Government which press upon individuals are continually thrust before the public, we may never know the thousands of times when the individual gets the benefit of a doubt or is the recipient of a wise liberality.

It may be called an Utopian idea, but I trust the day may not be so remote when Generals in command of tactical and administrative units, whether in India or England, shall have the power and responsibility of all administration.

That Army-corps system, of which Colonel Chesney and others have taught us so much, which has enabled Prussia to mount far up the ladder of military perfection, is no sudden invention. It was recommended 13 years ago for the Army of Bengal by His Royal Highness

the Field Marshal Commanding-in-Chief; it has been advised to be applied to all India by Lord Sandhurst when Commander-in-Chief in Bombay and in India; and it is that which recommends itself to every mind desirous of improving the organisation of the Armies of the British Empire.

Those who are accused of desiring to Prussianize the British Army may console themselves by the reflection that a time may come when their successful efforts to take what is good in a continental system, and throw upon it the light of our own experience, may be acknowledged by a nation retrieved from possible disaster, either on its own shores, or in the distant but glorious Empire we have founded in India.

The CHAIRMAN: Gentlemen, it is impossible to deny the great interest in the matter brought before us by Mr. Collen. I now invite gentlemen to make any remarks that they may think the subject deserves.

General Sir WILLIAM CODRINGTON: I do not know much on the question of "Transport in India," but I hope other gentlemen, who know more about the subject, will give us their remarks, which will be of great interest. There is one point I should like to ask about, viz., the transport of ordnance stores. I understand that there is a totally separate establishment for the transport of the so-called warlike stores, as distinguished from those of food and fuel. Do they keep an entirely separate establishment for that, and a separate arrangement for replacing horses and carts for the ordnance supply? Of course it is a very large question, which one not so intimately mixed up with Indian as with English transport can fairly deal with; but I dare say there are many gentlemen who can answer my question; or at all events the Lecturer will afterwards.

Lieutenant-Colonel HUNTER: I can only say myself, having been on the quartermaster-general's staff for many years, that for any transport in India the Commissariat staff is required. It does not matter what particular department requires transport, the Commissariat Officers are requested to supply it; and they on all occasions do supply it.

The CHAIRMAN: As it appears none of you are willing to enter upon further discussion on the very interesting matters which have been brought before us by Mr. Collen, I would venture, as one who has had very considerable experience of India, and as one who is under the greatest possible obligations to the department by which the armies of India are administered, to say that it is impossible to exaggerate the benefits imparted to those armies by the department to which our attention has been drawn this evening. I will not confine your attention simply to the small operations which have been alluded to by the Lecturer, namely, that little campaign of Huzara, which was organised when I was in command of the armies of India in 1868, and the late expedition in the Lushai country, which seems, as far as I can judge from the reports, to have been admirably done. At all events, it is on a small scale. But I will draw on my experience from my observations of campaigns conducted on a very large scale by some of the Commanders-in-Chief, who preceded me in the command of the armies of India. I would refer to the campaigns which were conducted by Lord Gough, also to those conducted by Lord Clyde. During all those campaigns, and in the midst of the vast and extended operations that were conducted, I will say this, that having a personal experience of what was done, it never happened that a soldier wanted his ration, or that a horse died from want of food. When you consider over what a vast area those operations extended, what were the difficulties with which the Commissariat Department had to contend, I venture to say that there are no establishments in any other country, and there is no department in any army, either in Europe or in any other part of the world, which is able to make a boast of that kind, and with perfect truth, to which I have drawn attention, as regards the Commissariat of the armies of India. Whilst it was my duty on various occasions to call attention to these facts, and to place them on official record, and as one who has been Commander-in-Chief in India, and who as chief of the staff under the late Lord Clyde, had to pay the greatest attention to the

details, according to which those armies were supplied, I venture to say that it is impossible that the excellence of that department can be exceeded. And when the gentleman who has favoured us this evening dwells upon the necessity of what is called a greater military development, I think we should pause before we interfere with the system which has worked so well. I have it in my recollection that in one of the great campaigns of Lord Gough, it was much feared that the Army would not be able to advance and to perform the duties required of it by the Commander-in-Chief, because of an apprehended failure of supplies. Well, what happened? The Commissary-General of that day, General Ramsay, was in the most intimate connection with the great contractors of the country. One whose name was very familiar 20 years ago to men who served in India, Jotee Persjad, though not known in England, was able to come to our assistance; and by the exertions of that great contractor, the Army was able to advance and to perform its duties in a manner which amply redeemed the reputation of the Commander-in-Chief, and obviated even the slightest delay in the operations. Now, that is in exact conformity with the principle which was lately laid down by General Trochu in that admirable pamphlet which he wrote three or four years ago, about the reforms required for the French Army. He there pointed out that if any French Army were to continue to rely entirely upon a military organisation of supply, it would be very likely to fall into that kind of weakness which results from purely departmental management, as distinguished from availing itself of the national resources of the country. If you depend entirely upon a military organisation, you restrict yourselves, as it were, to the skeleton of supply. But if that organisation is so formed that you are connected with the great contractors, with all those civil elements of supply, which form not merely the skeleton, but the flesh and blood of a country, then an Army is sure to be supplied, and the operations are tolerably sure to succeed. This is the reason why I, as Commander-in-Chief, invariably opposed a radical change in the formation of the Commissariat Department of India. I considered it absolutely necessary that we should rest on the principle that the military department of the commissariat should gather within its folds all the resources of the country; and that if you went for a too military organisation, you would then cease to command all those resources which, happily, have been at our disposal hitherto. Well, the result of that was seen in the most remarkable manner in the operations conducted, first, by Sir Henry Havelock and General Outram, and afterwards by Lord Clyde, in the campaign of 1857. At that time we, literally, over many hundreds of miles, merely commanded the lines of communication between Calcutta and the seat of war. That is to say, we had command of the road, and we had command of the river; we could not go five miles, either from road or river, without going through the business of a military operation. Notwithstanding those difficulties, notwithstanding the fact that a country which for a hundred years before had been just as peaceable as the county of Middlesex, notwithstanding that country suddenly became absolutely hostile, and that every man for the time being was against us, as far as they could show their hostility, still such was the influence of the native contractors who worked under the Commissariat Officers, that the supply of the Army went on just as if we commanded the country as well as the roads. That would be quite impossible if we had not had that complete network of civil communication with the military department of the commissariat. Therefore I think that it would be dangerous to interfere with the form and the action of a department which has worked so well. With regard to the question put by my gallant friend, Sir William Codrington, I would mention that the ordnance supply of transport, to the best of my recollection, is drawn from the commissariat for purposes of war, and for the purpose of movement of the troops and field batteries from one station to another, just as it is done for other branches of the service. As was explained by the Lecturer, I think the siege trains are maintained by the Ordnance Department. Those siege trains include a certain number of bullocks. I believe that in time of peace their numbers are not kept up to the full quota, as is required in time of war. Still there are always siege trains in a certain stage of preparation, which are ready to move at a very short notice indeed. With respect to the supply of horses, which I think was also included in Sir William Codrington's question, that is an affair which is regulated in different ways in the several Presidencies. In the Presidency of Bombay we depend entirely

upon the purchase of horses, which are principally Arabs and Persians, that come from the Persian gulf.

Sir WILLIAM CODRINGTON: I meant transport horses; the horses for transport of the *matériel* of war.

The CHAIRMAN: I will treat of that in a moment. The horses in Madras are supplied by purchase in the same manner from north of the Persian Gulf, and partly from Australia; and also they have a depôt of horses, where the latter are maintained for a certain time before they are distributed among the troops. The great army of Bengal depends for its horses upon the studs, where the horses are bred at great expense to the country; and also on the importation from Australia. With respect to transport horses, there are no such things in India, if we except the horses that are attached to the carriages belonging to the guns. All the transport in India depends, as was explained by the Lecturer, upon other animals. There are elephants, camels, and bullocks, and in mountainous countries we have mules; and there are dooly bearers, and different kinds of men of that sort. But horses are not used in India for the purpose of transport, as they are in Europe. There was a point which was mentioned by the Lecturer, bearing reference to the concentration of arsenals. When I first went to India, there was a great number of arsenals and magazines. As the system of railways came to be developed, very many of the smaller arsenals and magazines were abolished; and, as was pointed out by the Lecturer, the large arsenals —they are not new—have been very much developed at certain strategical points, the smaller ones having been all swept away. This, of course, is a matter of military convenience, and also of safety in case of a general insurrection. It is a necessary precaution, which was not possible as long as we had a great number of native powers who maintained separate armies, and were likely to go to war with us. Now-a-days those armies have mostly disappeared; the native powers have ceased to have any consequence whatever. In addition to that, our system of railway communication enables us to do with half-a-dozen arsenals for all India; whereas in former days the want of roads impeded such concentration. The moveable columns have been admirably treated of by the Lecturer; I can only say they are a modern feature in the Indian armies. They spring from our experience of the danger of leaving the district in which the country is divided, without means of moving a single soldier at 24 hours' notice, which was the case before 1857. These columns were formed, in consequence, to meet that difficulty. They have answered their purpose extremely well; but it must not be supposed that the means exist of concentrating those columns, to form the carriage of a *corps d'armée*, which might, perhaps, have been gathered from a sentence that met my ear in the lecture. The truth is that these columns, as shown by the Lecturer, are distributed over a vast area of country, and their concentration is impossible. It is very unlikely indeed, we should ever have again to assemble a large army in any part of India. Where there is a railway terminus, we should, to meet the wants of such an army, generally have to depend upon such carriage as the district of the country could afford where that terminus might happen to be. But we must guard ourselves from believing that the moveable column carriage would be of much service for that purpose, because the moveable column carriage is essentially an affair of local character, that is to say, that each station of some importance has its own column of transport, which cannot be alienated from it, except for the purpose mentioned in the lecture, namely, for aiding the civil power and carrying out the ordinary reliefs. I think I have no further remarks to make; but I would beg to offer the thanks of the meeting for the very excellent lecture to which we have listened. I may from my own personal knowledge bear witness to the exceeding exactness of the details with which we have been favoured. I do not think it is possible that we could have listened to a clearer narrative of the system that prevails, and of the advantages which are drawn from it.

LECTURE.

Wednesday, June 19th, 1872.

Lieutenant-General the Hon. Sir JAMES LINDSAY, K.C.M.G., Inspector-General of Reserve Forces, in the Chair.

AUTUMN MANŒUVRES ABROAD AND AT HOME, 1869—1871.

By General Sir William J. Codrington, G.C.B., &c.

The Chairman: General Sir William Codrington requires no introduction from me to the members of this Institution, nor to those who are in the habit of attending the lectures here. The information which he will give on the subject of "autumn manœuvres"—which are now engaging so much attention—will, from his knowledge of those he saw in France and in Prussia, as well as those he has seen in England, be, I am sure, of a practical character.

Sir William Codrington: The following remarks relating to "Manœuvres Abroad," are founded upon notes made at the Camp at Châlons, in August, 1869, and at the Prussian manœuvres in September of the same year.

The remarks on "Manœuvres at Home," are founded upon notes made in 1871, during the movements in the neighbourhood of Aldershot.

In the year 1857 I attended unofficially the manœuvres of a French corps at Châlons, of about 20,000 men, as well as those of the Hanoverian Army, forming, with the contingents of Brunswick and Mecklenburg, &c., the 10th corps of the then German Confederation, amounting to about 25,000 men. There were 68 foreign Officers present at these German manœuvres. In Hanover, in France, and in Prussia, an active and hearty kindness has enabled English Officers to take part in the manœuvres; an example long given to, and last year happily followed by, this country towards foreign Officers, with sufficient liberality and success to justify a hope for its continuance.

The principles of strategy form a subject scarcely to be dealt with in notes on manœuvres, or in an hour's lecture at this Institution. The following remarks refer more to details of tactics and equipment;

they may to some be without interest, or appear trivial; but to those of my own profession excuse is unnecessary. As no principle of strategy, no consideration of tactics, can be too high for thought, so in ours, the most practical of all arts, no detail can be too small for that attention without which even strategy might fail; for its combinations may depend upon the soldier's shoe, the farrier's supply of nails, the dampness of powder, or the absence of cartridges at the decisive moment.

From these notes I have now omitted details relating to electric telegraphs, and remarks not strictly on military points; but in the remainder no material change has been made, either in their substance or wording, since the time when, by order, they became the subject of official report.

Camp of Châlons, August 15, 1869.—The défilé of the troops then took place, about 20,000 men. The infantry marched past first: a very good precedence over cavalry and artillery for many reasons. It is well known that in the French movements and even parades, there is no minute attention paid to the regularity and dressing of companies; each general of division and brigade gave the sort of signal cry of "Vive "l'Empereur," "Vive l'Impératrice," "Vive le Prince Impérial," as he passed the saluting point, and each company by its commander did the same as it passed in a quick but loose order of marching. The knapsack is of the usual brown cowhide, with the hair on—a serviceable material. The great coat was carried rolled round it, in which position it drags less against the shoulders than it does with us when folded at the back of the knapsack; a tin water bottle covered with grey cloth, more handy to carry than our large round wooden one; a small mess tin made in one piece of iron, and tinned without any soldered joints; a tunic, and the loose trouser of good red madder dye; a low shoe, well nailed, with a white linen gaiter, these form the outside dress and equipment of the French soldier for parade.

Certainly the strap of a gaiter may wear out, but it is broad, strong, and easily repaired; and a low shoe (compared to our English ankle boot) is cheaper, better for marching, can be put down at heel in case of blister, and thus enable a man to limp on with his battalion. But every soldier should be able, by a light strap, to tie in his loose trouser under the knee; for nothing facilitates walking, or hard working, particularly in wet and dirt, more than thus taking the weight off the knee.

The general appearance of movement of the men of the line is an easy activity, which we should probably call a looseness of marching, the swinging the arm seeming to help them as it does Spanish and Russian troops, and giving an apparent energy and freedom which is wanting when the arm is held stiff down the side.

The men were in the formation of two deep, had Chassepôt breechloaders, with sword-bayonet. They carry a ball bag with 10 rounds, a small pouch with (probably) 30 rounds, and the rest in the knapsack; this latter is a questionable place for it. There is one battalion of Chasseurs to each division; Officers and men selected for activity, endurance, &c.; but such selection is like taking cream from milk,

though it may have its advantages occasionally. About 40 battalions marched past, some few being "Infanterie de Marine," some Engineer companies. From dust and other circumstances I could not then judge of the real size and apppearance of cavalry and artillery horses, which passed at a trot. The "artillerie montée," or field batteries, mount two men on the limber, and four men on the waggon, none marching on foot, but they carry their knapsacks and a carbine slung across the body. The cavalry at the end of the défilé formed into line opposite, and charged up to us, keeping good line, but at no great pace. This terminated the parade. The artillery horses are harnessed, not with the collar, but with the *bricole*, or breast-band. It is certainly simple, inexpensive, and does not get out of order; but probably the collar is a more efficient means of applying the power of a horse to heavy work. The cavalry have also for their equipment a light breast-band, which can be turned to advantage in assisting artillery in difficulty.

August 16, 1869.—The Prince Imperial and all the Staff went on horseback round the camp. First to the cavalry horses picketed to a ground-rope, and by one fore-foot only; not so powerful or so good-looking as our own.

Then to the artillery; horses picketed to a rope breast-high, and fastened by the head. Not much show in the horses, which neither in power nor breeding can be compared to those of our own artillery; they have only four horses to each gun, which may be sufficient for peace, and this firm ground; they use the pole, not shafts. There is not much difference between the horses of the "artillerie à cheval," and the "artillerie montée" in this camp; the horse artillery gun detachments are of course mounted; they march past in rear of their guns.

Then to the infantry lines. There are permanent huts for one division; they are good-looking, and apparently well-built; timber frames filled in with a nice-looking reddish-coloured brick, good roofs of slate, and projecting eaves. The huts for Officers and men seem to be alike in size; the sergeants live and cook and eat entirely separate from the men, nor is there any social intimacy even between sergeants and corporals; they all mess in separate ranks, with a decided demarcation. In camp the Officers have general messes together; but in garrison towns they mess together only with their own ranks, and without an established mess.

The majority of the troops are under canvas; the tent is a bell tent, to hold 15, but now with 12 men, a centre pole, and means of ventilation at the top; but there is scarcely any wall to the tent, though there are two sets of tent-pegs, one at the ground, the other with the stretching lines. The tent is low, but with a larger circumference than ours. I doubt its being as convenient for the men, in consequence of the low wall; there are two openings, one a triangular door, as with us; the other can turn up, supported by two poles, making a convenient door.

The men of the infantry of the line were small, but able-bodied and active, many of them young-looking, arising from their time of conscription; the Chasseur battalions, being selected, are firmer looking. There were some Crimean regiments, but few of the men had the medal,

though a certain number of company Officers wore it; the Officers commanding battalions and brigades seemed younger in proportion than the company Officers.

Frequently the *drapeau* was placed horizontally across two sets of piled arms. The arms of a company are piled together under a covering small tent on the alignment of each company, and it is called a "manteau d'armes." This is a better arrangement for peace than for service.

The soldier has two meals, and similar ones, per day; the first with soup, bread, and meat at 9 or 9.30 a.m., the second at 5·30 p.m.

August 17, 1869.—On our return to camp we went into some new storehouses, to be increased, well built in a similar style to the huts, though of course larger. They contain carriages for the train, ambulances, cacolets, litières, pack-saddles, &c., the commencement of a store establishment for a considerable army supply on this, an important strategical point for France. For Officers' baggage, a two-wheeled one-horse cart, two such carts to each battalion. Each Officer will now be required to purchase one of the boxes which is fitted in with others; a canteen box also among several. This will be the official limit to Officers' baggage. I saw a similar arrangement with the Sardinian Army in the Crimea.

Water is found all over the ground of this camp at a level of 10 or 12 to 20 or 30 feet below the surface, according to hills and depressions. It was the first and principal consideration in recommending the purchase of the ground that the supply should not depend on the small stream at Mourmelon, or any other running water, but upon wells. And having made many successful trials in finding water in all parts by boring, it was recommended for a camp and exercise ground.

At half-past two, manœuvres of the troops. The Government ground is a space enclosed by sides, each of which may be roughly estimated at three leagues; chalk soil, dry to a degree, and healthy, a sort of inferior sparse grass growing upon it showing the chalk through, hard, excellent and easy for all arms to march over. It is a gently undulating surface with long slopes, nowhere steep, though sufficient to hide large bodies of troops. There are a few pine woods, the trees small in size, and some stunted pines in long rows here and there. One might see all the manœuvres, and accompany them, in a calèche.

The manœuvres took place about three or four miles from the headquarter pavilions. The idea given by General Bourbaki was, that an army coming from the east had obtained possession of the long line of height which overlooks the undulations towards the camp, and had also seized a wood and ground in advance of his left front, by which the junction of one of the three defending divisions was endangered. This detached division was to attack the wood and manœuvre to its left to join the main body. When the junction was secured, a general attack by the three divisions united was to be made on the enemy's front, whilst cavalry and horse artillery turned his right.

The movements were undertaken in this view of course without difficulty. Judging from our central position, the troops were extended over a large space, and with considerable intervals between regiments.

The infantry were in the formation of two deep, with skirmishers in front, and generally attacked in line, though some were in the usual double column of pelotons. When the detached division had secured part of the wood and its new communication, it passed to its left in rear of the other divisions, which were ordered during this movement to make the general attack, orders being also sent to the distant cavalry to turn the enemy's right. The attacks were made partly in line two deep, skirmishers in front, and partly in column. The troops moved actively, but, as we should say, loosely, as is their habit; and we should insist upon the prudence of having less intervals of space between regiments. Sometimes the skirmishers and supports were formed from regiments, sometimes from the battalion of Chasseurs. The firing was principally *à volonté* (file firing) but occasionally by companies. The cavalry movement on the left was so distant that we could only see a small cloud of dust created as we moved in advance. The attack, therefore, was extended over a large space of ground for such an operation by about 17,000 or 18,000 men. It is certainly good hard marching ground, but the troops had come some distance from camp; they moved actively during the manœuvres; they had a considerable march home. It is scarcely necessary to say of any portion of the French Army that it marched with soldier-like activity and efficiency. The French soldier on march, such as this day, wears his small shako, his capote or long great coat, of which the front skirts are turned back for ease of movement, his red pantaloons tucked inside the white gaiter which comes some way above the ankle. The tunic is in the knapsack, the *tente d'abri* round it, with the sticks to support it cut in half, and placed up and down the side of the pack. The firing with the Chassepôt was of course quick. A certain few ramrods were used to put out of the breech a failing cartridge, but I did not see many of these. I did not see any other battalion movements than an occasional forming line and column in their usual manner on the front of two centre companies or pelotons. It has always been their habit to attack with a large body of skirmishers, and I imagine they will strengthen that system in future.

Each Division General has his distinctive "fanion," or colour (camp colours in size), carried by one out of five or six cavalry orderlies. Here one was red, one blue, one yellow.

August 18, 1869.—On horseback, to see rifle and artillery practice. The targets and butts are about two or three miles off, with interminable power of range, there being no population or houses; but the line of artillery fire is kept clear on a broad space by mounted men. The first practice was with the Chassepôt by 200 men, two deep, firing at a continuous canvas target of about their own length of front, and at 200 mêtres another target, behind it, at an interval of 100 mêtres, and two other similar targets with 100 mêtres interval—in all 500 mêtres. It was supposed to show the men that even if they missed the first line their fire would be effective against troops in rear. The targets, being continuous, were well riddled in the three or four minutes firing *à volonté*, and there were were many shots in the further targets, of course, for rifle shots going through the first went also

through others, as all were of canvas. There was also some battalion firing at 800 mètres, powerful fire. But the best experimental practice was the skirmishing of a battalion of Chasseurs in marching order at a long line of separated single and double targets at 800 mètres; then, after advance, at 600 or 700 mètres; then again, after similar advance, at the double; then, after retiring at a good double, at various distances. I do not know the proportions of hits, but this open formation of a battalion of Chasseurs, yet with ease of closing files if necessary, makes a very formidable means of attack, for they were not employed strictly *en tirailleur*, loose and extended, but I presume their closer order and good alignment was intentional for its particular purpose. (I understood the hits to be one-fourth, or 25 per cent.) The next experiment was to show the possible effect of a fire of infantry upon troops assembled as a reserve inside a redoubt, and not under the immediate cover of a parapet. Nothing could be seen from the firing detachment at 800 mètres distant, except the white chalk low earth-work; but canvas screens in two rows were set up in the interior, one at about 10 yards, the next parallel to it at about 15 yards from the parapet. The firing from about 200 men took place against it, the sighting of the rifle to be 1 millimètre above the crest.

The targets were not very much hit, nearly as many in the second, as in the first target; but enough to do damage and to shake *morale*, though in reality, men defending such a work would have been close under the parapet and out of fire. I saw the rapidity of the Chassepôt tested by the Officer Instructor firing 17 in the minute—the cartridges, however, were ready loose in a man's hand at his elbow. It is lighter than the Snider; it has a sword-bayonet which makes it, when fixed, heavy at the wrong end, but the French, as we ourselves now, do not habitually fire as formerly, with a fixed bayonet or sword.

We then saw shot-practice by the artillery; 10 guns of "batterie "de réserve, pièces de douze," brass guns weighing 11 cwt. English, the shot weighing 24 or 25 lbs. English; rifled guns, elongated shot with brass studs. It is a hollow shot when stopped as now with a lead plug; or a shell, with a brass screwed-in fuze. The practice was a known distance of 1,200 mètres. The firing was short, and they had to increase the elevation to that for 1,500 or even 1,600 mètres in consequence, it was said, of the "rayures" being very much worn from age. The fuze is a brass fuze, both for these pieces and the field "pièce de quatre." It seems it can be bored only for four distances, and does not seem so advantageous as the Boxer wood fuze.

We then went to a line of 10 or 12 guns, field batteries and horse artillery with "pièces de quatre," *i.e.*, 8 lbs. weight of shot. They fired shrapnel, but they mostly burst much too high for troops; the range being 1,200 mètres, the artillery Officers seemed to think that it was more fitting for the "pièces de 12" than these field guns. Want of time prevented our seeing an experiment of interest—that of using field pieces with very small charges and given a high elevation in order to damage artillery in works by a sort of perpendicular fire of shell. The dummy guns and detachments were put up inside a gabioned field-work which we passed; but to the disappointment of the artillery,

who had been long there, and of ourselves, the experiment was not made.

August 27, 1869.—At Frankfort I had the opportunity of visiting the camp and bivouac of some Prussian troops. Four guns, a battery on peace establishment (the war complement being six guns) attached to a brigade, had just come in from a supposed "alerte." The gun and limber had its six horses: no waggons. Three men sit on the limber box and two men on the carriage of the gun itself, one on each side of the gun, and protected by a bent iron rod, as it may be termed, between the wheel and the gun, a leather seat on the axle, and a small support for the feet; very little space, and must be considerably knocked about.

A Non-commissioned Officer is mounted, and these five men work the gun, which is a breechloader of steel with rifle grooves similar to the Armstrong, the breech closed by a close fitting cylinder passing through it horizontally. The gun seems limbered up to a pin or crutch attached to a continuation of the pole passing under the limber. The guns were left as they came in, limber to the front, and the horses were placed in a line in front at the side of the limber, enclosed by a rope from limber to limber, and tethered by the head. They seemed thus to be placed handy for their purpose. The gun seemed about the same bore, but heavier than the Armstrong.

The horses with very long traces, serviceable animals, but not the size or power of our own. The wheel of the gun-carriage about the height of ours, being higher than the French; the wheel of the limber considerably smaller than that of the gun; the nave of the wheel is iron, the spokes of wood, with a continuous tire, and the Officer said that a damaged spoke could be taken out and replaced by unscrewing at the felloes. Went also to the bivouac of a cavalry regiment, the 5th Dragoons. The question of sore backs was made an important one by the Commanding Officer, as with other cavalry Officers; and he mentioned with pride that although his regiment with five squadrons had been out some time in drills and manœuvres, he had no sore-backed horse. The saddle is composed, as with us, of the two shaped out sides of the tree, wood; and then the usual blanket next to the horse. Some of the trees had straw laid lengthways along the tree, and sewed to it as a flat mat of its size and shape, and about half an inch thick. Then being cut out, chamfered out at any particular place, it eased that part of the back on the least commencement of swelling or irritation, the object of all his orders and inspections being to insist upon the least beginning of inflammation being made known in its earliest stage. It seems a simple way of prevention or remedy. The man's kit is carried in holster bags, no valise, the cloak rolled behind the saddle. The horses passed going to water: a horse of good size, but better in fore quarters than in hind, where he was somewhat lanky and unknit. I then went to the infantry. The regiment is of three battalions, and was divided, as usual in the Prussian Service in the field, into three parts, the "gros" being the main body, throwing out to its front "vorposten," and having also a rear guard. The battalion on halting, piles arms in column, close column, or something similar. Then each

company is moved out on its alignment to the right or left to put down their knapsacks, each man subsequently using his own for a pillow as he lies amongst the straw which is served out to them almost in profusion—as indeed one may say of the logs of firewood. A certain portion of the straw is twisted or plaited into a broad band and somehow wove into the upper part of the sheaves of straw; the whole then stands up, forming a hedge of a square or a circular form, enclosing the rest of the loose straw which the men lie upon. The wood and straw brought by farmers' carts is resold by the Commissariat on the troops quitting. The cooking was going on: the soldier carries his tin can—a larger one than either French or English—perhaps unnecessarily large—placed across the top of his knapsack. They carry no company tins for six men as we and the French do, nor indeed can these be depended on for service. The usual small trench was made for the fire, each company cooking for themselves. When near a village they borrow, if possible, a large cauldron in which they make a general soup and meat hodge-podge. After assembly for roll call, the band of the regiment played a hymn prayer, the men remaining uncovered; and each regiment did the same in various parts of the camp bivouac.

Monday, August 30, 1869.—To the parade of the Corps of the Guard at Berlin. The troops were drawn up in two lines, infantry in contiguous columns in front, cavalry and artillery forming a second line. There were about 13,000 or 14,000 infantry; some two or three battalions were of older and more formed men, but many battalions were of younger though good sized men, but very few medals and old soldiers; those of 1866 and its campaign had lately left the ranks, having served their time, but there were many Officers with medals. The infantry go by first in all their parades, a very good plan for many good reasons; it was this infantry of the guard that had seized the village of Chlum in the centre of the Austrian line at Königrätz. A detachment of drumers, with some senior drum-major, was, during the whole défilé, placed opposite the saluting point, and on a battalion approaching gave the time, and continued beating until the battalion drums were near enough to fall into the same time and take it up; this seemed to prevent any hesitation in the step of the advancing battalion.

The men of the infantry marched past steadily and well, but with the curious show manner of putting out and bringing back the foot with a bent knee. It gives an artificial and affected look to troops that are not at all of this character. The time was about the same as ours, the firelock at the advance. The colour is carried by a sergeant, and singly, on the right flank of one of the companies.

There are battalions of chasseurs, selected men, and there was one battalion formed by a few Non-commissioned Officers and men from almost every regiment in the service, as a means on returning to their regiments of assimilating the marching and arrangements of the whole army.

The helmet with the spike at the top is the general head dress for the infantry—it must be heavy and uncomfortable; the men had their packs, generally of cowhide; the chasseurs had badger skin packs, one pouch, but on service two, one on each side towards the front. They

had, of course, the needle-gun breech-loader with bayonet, for which they have no scabbard, therefore it is always fixed; they have a sword besides, but the chasseurs have simply the sword-bayonet and scabbard.

The cavalry came next, the Garde de Corps and Cuirassiers of the Guard, white uniform, helmet with eagle at the top, long black thigh boots; their horses are of good size, no brass or bright buckles about them, and the leather left its brown colour. They went steadily by, and looked very well. The lancers with black and white pennons the same, but the horses smaller and lighter. None of the cavalry horses as powerful as our own. The artillery came last, 4 guns to a battery in peace, 6 horses to a gun; on the limber of the field batteries 3 men, on the gun-carriage itself 2, as I have elsewhere described. They carry 42 rounds per gun without waggons. Horse artillery has a lighter steel gun, I believe an 8-pounder, but the denomination of their guns is understood to be neither simple nor good; the horses are serviceable but not equal to our own.

The men now in the ranks are young, from others having completed their active time last year and gone to the reserve; this accounts for the few medals in the rank and file.

The system of the Landwehr was formerly rather a deception as to efficiency, for it consisted of many men who had only served in the Landwehr itself; many were old, many incapable. Now, every one of the Landwehr must have done army service in the line. In exacting the personal conscription for the army, a man who is physically incapable is not let off entirely; he has to pay a "steuer" or tax, and it is considered properly so, for all others pay this heavy personal tax, therefore he must pay in money if he cannot in person. The object of the whole system is not only to make the nation military in fact, but to induce it to take an interest in being so.

August 31, 1869.—To Müncheberg, about 25 miles east of Berlin, to see the manœuvres of the third, or Brandenberg *corps d'armée*. About 18,000 men were posted in two lines, infantry in front in close columns of contiguous battalions, but with considerable intervals; cavalry and artillery in a second line. In the défilé which took place, infantry of course first, the men young, but able-bodied steady looking men. They marched past by companies in quick time well, with good steadiness and alignment, although with what might be called a "prancing" step. This manner of parade marching does not look really soldierlike. Though it is principally a matter of parade, such customs become sometimes identified with the feelings of soldiers, not lightly to be interfered with; but being a habit, possibly not a good one, I saw some advances over dry and dusty plough ground partake considerably of this habit. Blue tunic, black leather helmet, cowhide knapsack, hollowed out for the back, great coat carried across the shoulder and pack, one small pouch (a second added in war), the large tin can horizontal on the top of the pack, a small water-bottle and haversack, white trousers (part of a parade dress for the King), boots, a sword, the needle-gun with bayonet fixed, this was the dress and equipment of the infantry soldier. They went by also in line of con-

tiguous close columns of regiments, *i.e.*, a front of three battalions, their colours in advance; they marched capitally, and columns always look well and powerful in such a movement. A very good parade show is formed when cavalry pass, by the Non-commissioned Officer or man with the kettle drum passing first in front, and alone, beating what I suppose is termed a "point of war," with a manner that would do credit to a French Tambour-Major, the trumpets coming in occasionally with a similar point of war. Five squadrons to a regiment, and strong ones, but little ornament of buckles, &c., about the harness, though some of the hussars had a long pointed and laced shabraque, which took away from the size of the horses, and must be an useless affair. The horses serviceable, but not large, the whole soldierlike, except those long shabraques. A corps is generally composed of 25 or 26 battalions of infantry, between 50 and 60 pieces of artillery, and 30 squadrons of cavalry; its infantry in peace is about 500 men per battalion, in war to be completed to 1,000, divided into four companies, the Captains commanding which are mounted.

The military arrangement of Prussia for conscription, quartering, drill, and manœuvre is by a division of the country into districts for *corps d'armée*, generally conterminous with the demarcation of provinces. Thus the 1st corps is raised, maintained, and localized in East Prussia; the 2nd corps in Pomerania, the 3rd corps in Brandenburg, &c. There are 12 such divisions and *corps d'armée*, besides that of Hesse, and the corps of the Guard. The preliminary drill of recruits, battalions, and brigades, and, finally, the assembly of each corps for the autumn manœuvres take place within the province itself, the men when manœuvring being quartered in villages or bivouacking in the open. Where a conscription is so large and general, this localizing the corps must have the advantage of interesting the families of the population in the well-being of the corps, and must render less irksome the quartering, the damage by manœuvring (which, however, is always paid for), and the conscription itself. It may, however, give some idea of the pressure of conscription, as well as the military power of one continental nation—to which others probably are not inferior—to remember that the army which England landed on the shores of the Crimea was 27,000 men; but that a number equal to at least *nine* such armies, complete in infantry, cavalry, artillery, and transport, without counting reserves, invaded Bohemia in separate corps in 1866. It was one of these corps, the 3rd, on its peace establishment, the manœuvre of which was carried out to-day. The orders were given, and their execution carried out, with quietness, decision, and promptitude. The country was generally quite open, with long, even undulations of plough and no fences. The general plan was an attack upon the village of Müncheberg, situated on the crest of a gradual slope, and with advances and retirements in the centre, according to supposed occupation of farm-houses by an enemy; at last to bring forward the whole right wing to turn the left of the enemy and throw him back beyond the chaussée marked by a line of trees.

The attack of Müncheberg began by an infantry brigade; skirmishers in advance about 1 or 2 paces between each file—rather close

as skirmishers—supports in column of sections in rear very close to the skirmishers—and the portion of the battalion in column of companies—also very close to the supports; too much so, indeed; for if we suppose the village of Müncheberg occupied by infantry and guns, the artillery would have reached and decimated, at 12 or 1,500 yards, such concentrated marks as the section column and the battalion. The village and mill, or part of it, being supposed to be held by the attacking party, I rode to other parts of the field. Similar attacks by infantry not preceded by the fire of artillery, took place against some farms and gardens in the centre, *i.e.*, by skirmishers, occasionally reinforced from supports which remained close, and the battalions of companies also close, and running up, charging with fixed bayonets, in column. The artillery, generally in rear at considerable distance, and firing over the heads of advancing infantry—a somewhat dangerous practice—and, of course, the rear position prevents range being as effective as from a front position; but there was one occasion in the centre that I saw the horse artillery come well in front of the troops. The cavalry, consisting of 25 or more squadrons, were all massed on the right rear, moving to front or flank occasionally; they were well concealed in the early part of the day; but from the enemy's hill in front they had been seen and exposed to fire by the valleys running in a direction favourable to their being enfiladed. They moved, however, very steadily and well. Dust there was in plenty to obscure cavalry movements of detail; only one regiment, the Ziethen Hussars (in red), were brought forward to charge, and from others competent to judge, I heard that they were well in hand in everything. When the right of the infantry and a portion of the cavalry had thus come into the new alignment, there was a general advance, driving the enemy to the chaussée marked by the line of trees. I remained in the intervals and in rear of three battalions (small ones) advancing in actual line; they did so at a quick pace, drums beating; it was a steady good advance for a considerable distance over dusty plough, and uneven ground, but it was well done. Then the manœuvres ceased. The men did not look at all tired; dusty enough—but that is all.

The usual infantry formation is three deep, in order to take the third rank out as skirmishers. Thus the front of a company or a battalion is not diminished; and even if in three ranks, fire could be given with the front kneeling. The Jäger Battalions are formed two deep,—there is one to a corps. Several men in the ranks carry tools—one in ten—such as picks, spades, axes. There are no battalion pioneers in a body, as with us. The Prussian soldier has a boot up to the calf, the trouser over it; but in dirt the boot is outside; though we should not think it good for marching, yet it is the habit of the country, it is simple, and certainly keeps out stones and dirt. The fire of the infantry was given frequently by word of command to sections or companies, or to the battalions, and sometimes by file-firing—it was, of course, rapid as breech-loaders are—it seemed to require a considerable knock with the hand upon the projecting lever.

September 5. *At Stettin.*—To the parade and manœuvres of the 2nd corps (or Pomeranian Corps) which were to take place in the

open country near Stargard, a town about 16 miles east of Stettin. Between fifty and sixty foreign Officers, twenty-one of them being English, attended these manœuvres; some few were sent officially, but all were recognized as the guests of His Majesty the King of Prussia. Nothing could exceed the liberal hospitality with which all were housed, either with private individuals, or when at the hotels, by the order and at the expense of the King. Upwards of forty carriages, each with its special number, were placed every day at Officers' disposal to ensure communication to and from the railway, their presence at official dinners, &c. On arrival at the manœuvre ground, 50 or 60 horses of the cavalry were ready for their use, and an Officer, Major Baron Korff, of the Dragoons of the Guard, was placed in charge of these arrangements, sending to us each evening in writing a detail of where and how and when we were to meet, and at what hour and where we were to assemble for dinner. Right well and agreeably was this duty done, and it was one that required attention to minute detail, good tact, and good temper.

September 6, 1869. *At Stargard.*—To the parade of the 2nd corps, 26 battalions of infantry, in a first line of contiguous close columns of about 500 men each; some of the battalions not quite such large men as the Corps of the Guard, but very good specimens of young able-bodied soldiers. The infantry in white trousers, being a parade for the King, but otherwise in real marching order. We rode down the line of infantry, and then down the second line, composed of cuirassiers in white uniform, dragoons in light blue, and lancers, in all 30 squadrons. In the same line, 16 batteries of artillery. At the défilé the infantry again first, column of companies at 22 paces distance, ranks three deep. They marched very steadily and well, with less of that peculiar step which I have before mentioned.

They were subsequently marched by in contiguous columns of regiments (three battalions each), steadily and well, with a good firm step, firelocks at the advance. The wheel of battalions at the angle was quickly, but somewhat irregularly done, at the double. The horses of the cavalry about the same as those of the guard, perhaps not quite so good, having a raw look about the quarters. The artillery horses of this corps seemed to me as good as those of the guard; without being large or strong they were active and serviceable in appearance. But we must not say they could be compared to those of our own artillery.

September 7, 1869.—By train again from Stettin to Stargard. Yesterday was the parade inspection, to-day the manœuvring of the corps. A dusty drive, partly road, partly field, of three or four miles, brought us to our horses, and joining in with the head quarter staff in a canter across the open country, ascended a small height suddenly, and looked down upon the whole of the 2nd corps massed in its position in readiness for movement. The 18,000 or 20,000 men of infantry, cavalry, and artillery, were well placed and concealed from the country and the enemy against which they were to advance, the enemy being designated by merely a few infantry and cavalry in extended order, in a position about one mile and a-half distant. The order to attack having been given, the advanced guard was sent out, cavalry trotting

up, and passing over the hill spread out like a fan to reconnoitre. Infantry and artillery were also sent forward, but no horse artillery. Then followed the main advance of the corps, with its infantry and artillery.

On this occasion the artillery were more used in advance or in line with the infantry. But still there was a habit, and rather a dangerous one, of firing over the heads of the advancing infantry. The same system of attack took place, skirmishers very close to each other, supports only about 15 or 20 yards in their rear in section columns, and the remainder of the battalion about the same distance from the supports, and in close column. The tirailleurs of the infantry of the line go to the front skirmishing with their bayonets fixed, because, having a sword, they have no scabbard for the bayonet.

The infantry constantly advanced against positions occupied by artillery, in column; and sometimes even deployed under immediate fire of artillery and infantry in position. This could scarcely be practised with impunity in war, nor could that of reforming the columns from line under fire for the purpose of retiring, which I occasionally saw done. But the attacking artillery, both field batteries and horse artillery, were well moved forward in masses, particularly on one occasion, when 20 guns were advanced to the crest of one of the long low hills and brought up the short steep pitch at a gallop. The guns had 6 horses, the limber carries 42 rounds, the men are carried on the limber and gun carriage, their knapsacks under the limber, and the men are thus ready at once to work the gun. There is something to be thought of in this different system from our own. The final attack to-day was upon the enemy's line, which had been strengthened by three or four redoubts in the plain, thrown up during previous engineering practice. The attacks were principally in columns of battalions closely preceded by skirmishers and supports. The company Officers and Non-commissioned Officers seemed during the whole day to be very attentive in regulating the detail of the men's movements in skirmishing, firing, &c., though here, as elsewhere, it is not easy to get men to act a reality when they see no reality of war.

The men marched well all day; some had come four or five miles from their cantonments to the rendezvous; the parade for manœuvre was about $9\frac{1}{2}$ o'clock, the end of the movements about 3 P.M., the country principally arable in the ridges, as left by the plough, and the troops marched back to their cantonments. Scarcely any men fell out, and I passed several regiments on their march home moving regularly and actively.

September 9, 1869.—To the town of Stargard, and after a canter of a couple of miles came to the village of Schöneberg, which, with the rising ground near it, was to be seized by a south army, in which position it was to be attacked by a north army. The *corps d'armée* on these occasions is divided into two divisions to oppose each other, one side having always small green twigs of trees on their helmets to distinguish it from the other. To-day the north army had 14 battalions, 13 squadrons, and 32 guns; the south army had 11 battalions, 15 squadrons, and 28 guns. A general idea is given, by means of litho-

graphed orders, to both the opposing armies; this comes from head quarters, and gives a strategical position of some larger forces of invasion, and of defence, from which the opposing divisions are detachments. Then there is given a "special idea" for each opposing army, which settles their position and the object of their movements, leaving to the two opposing Generals the strategical and tactical movements of their troops, by which they can take advantage one of the other, by rapidity, by occupation of ground, or the tactical use of the various arms in defence or attack. The decision as to where the advantage lies, what troops are to retire, and the prevention of too close an approach, is made by three superior Officers on the spot, who ride about together to all points of the field where a decision becomes necessary. They have a broad white band round the arm; their orders are obeyed at once, and they wear the sash as a mark of duty. Volley firing not to be within 250 paces, bayonet attacks not to be within 60 paces. The country was generally of the same easy plough undulations, entirely open, and no fences, but the hollow way of the Krampfehl gave a variety to the movements, though in crossing it from the north it was merely to feel for the enemy. This, the commencement of the day's manœuvring, was done with activity and apparent intelligence by detachments and single patrols of cavalry, who advanced quickly across country, observing and returning rapidly with information. Then the passage of the small gully and stream took place at various points by the north army, the movements principally in close columns of battalions, until they arrived in front of the southern outposts, when skirmishers were thrown out. The artillery seemed generally employed in positions to the rear of infantry, firing much over them, and frequently at very long range. The attack and defence, when near each other, took place as I have previously described, by skirmishers, close supports, and columns, and probably they would be much exposed in that formation to artillery fire, particularly in advancing towards a rising ground and village, such as Schöneberg, with its houses, fences, walls, and irregularities of ground. But supposing the formation the best for their purpose, the Officers of all ranks evidently take interest in seeing their men do their work properly. To-day was very hot, clear, and dusty; they moved very well throughout the day in marching order. No wonder that I saw one or two men lying as if dead, and that there are fallers out as in other armies; but the day was trying, some regiments had marched far to the ground, and I have seen many more men inefficient on such occasions elsewhere.

September 10, 1869.—To the same district as yesterday, that of Schöneberg. The northern army of yesterday was supposed to have forced the retreat of the south army from the Schöneberg position, which the north army now held to oppose the advance of the south army. The advanced posts of defence seemed well placed, cavalry detachment well concealed, artillery on a mound showing merely the muzzles of their guns; the horses and limbers well under the small advantageous crest. On the advance by the enemy, the reconnoitering by cavalry seemed well and actively carried out, though subsequently the enemy's artillery might have done them damage when in column;

nor, from some misunderstanding, did they retire till the enemy's skirmishers had long been firing upon them. But such accidental mistakes happen in all armies, more particularly when there is nothing to mark reality. The movements to-day were made more interesting by the intervention in the midst of the plain plough country, of one of those curious watercourses which form narrow but flat little valleys of grass with fringes of trees, and produce unsound marshy parts, impracticable for troops. They require a prompt reconnaissance, particularly by cavalry and artillery, previous to their passing them. All this gives admirable practice for General Officers, regimental Officers, and exploring parties. One of the decisive points of this day's manœuvre was the defence of a round fir wood standing on rising ground, with a deep, narrow drain or watercourse in the bottom within rifle range. Both were held at first by the defending party; but, of course, when the attacking skirmishers arrived near the drain, one party must go. So the defenders retired, although the attackers must have fared as badly in their open advance up to the drain, as the defenders must have done on retiring up the open slope to their wood. There was here distant artillery fire on both sides, battalions were moving about in columns; there was much musketry fire from a strengthened skirmisher-line, and by supports brought up for volley firing. At length battalions were got across this deep little watercourse, and went charging up the hill, with drums beating, and cheering, opposed in a similar manner by the defenders of the wood advancing their battalions and cheering. The Umpires were on the spot, and stopped closer advance; but, as soon as their backs were turned for another part of the field, a closer attack and nearer approach between the infantry took place with bayonets fixed, when some Officers of the Staff put a stop to further movements by galloping between them. There were many battalions in reserve for the defence of this ground, and there were many battalions ready for its attack, and I do not know how the matter was settled when the trumpets along both lines sounded the cessation. Although this was a shorter day, there was plenty of work for the troops, whose marching qualities and steadiness were very apparent, as well as the attention and intelligence with which their Officers directed them.

September 11, 1869.—The rendezvous to-day was at the old castle of Pansin, a place near the manœuvre ground of yesterday. The north army had retired, occupying the short and steep heights of the Klosterberg and the Heideberg, which commanded the valley and a deep drain close under their front where their outposts were placed. The attack of the south army began by infantry skirmishers with their supports, and the battalions approaching the position thus held on the Klosterberg and the hills near it: the steep, narrow ditch in the bottom being occupied, there was any quantity of firing at each other, the artillery of the defenders placed on the brows above the horses and limbers well concealed from fire. With various advances and retreats, it seemed considered too strong to be forced at that point, and I went to another part of the field where the passage of the attacking right wing was to be made. On the Heideberg, a good commanding rounded

knoll, were placed one or two batteries in entrenchment which could search the ground, like a glacis, down to the wood and bridge on its flank, by which the attacking enemy was to pass. It did so pass, and in close columns, which in peace was easy, but in war could scarcely have been attempted by daylight under the guns of the Heideberg position. But having now passed without loss, it could advance and turn the position, which it did, by marching on between this stream and a long lake to its right. It was therefore supposed that the defenders remained too long on the Heideberg; but, if in real war this flank march were made in column under an enemy's guns, perhaps the attacking force would never have passed at all. After the defending army had retired its left wing, the two armies faced each other, with the usual firing by skirmishers and by battalions, rarely deployed into line, and the trumpets sounded the close.

Here, as elsewhere, the truth of the saying is apparent, that "there "is nothing so unlike a real battle as a sham one." It cannot be reality for companies or battalions to stand still and fire volleys at each other at 70 or 100 yards apart, or at the same distance from a village in possession of an enemy: it cannot be reality to see cavalry as well as infantry halting or moving quietly in column under the effective fire of batteries of artillery; nor can it be reality to see artillery with their limbers and horses, quietly firing, when an enemy's skirmishers are within 400 or 500 yards. Of course these practices are neither ordered by regulation, nor are they universal; but they were certainly frequent; they may possibly be inseparable from a system of opposing one set of troops to another in peace; but if carried out in war would get sharp correction from an enemy. On the other hand, there is a great advantage to all ranks and to all arms in the independent movement of troops in country which they pass over for the first time; the easy or difficult passes for cavalry and artillery have to be found out and acted upon at once, and the very marching of men over varying and unknown ground gives greater practice and utility to drill and manœuvre: and this practice is a reality and valuable in a high degree. The result is that troops march and work admirably.

September 12, 1869.—At Königsberg, East Prussia. In the Lutheran church here, as in many others in Prussia, there are placed on simple tablets on the walls the names of all Officers and soldiers who died in the War of Independence, 1813—15, and who belonged to the district or parish in which the church is placed. Every name was legible, and it was recorded that they died the death of honour.

September 13, 1869.—To the parade of the 1st or East Prussian *corps d'armée.* There were under arms 26 battalions, 25 squadrons, and artillery with 60 guns. The infantry seemed as stout and as fine men as the majority of the regiments of the Guard Corps; able-bodied good soldiers in appearance; their white parade trousers did not look serviceable, but they were in other respects in marching order. There was not so much of that peculiar and somewhat artificial manner of marching past, and they went by with good steadiness, dressing, and activity, with firelocks at the advance. But when they had thus passed the saluting point, it was rather a relief to the eye, and to themselves

also, to see them with firelocks sloped and arms swinging, with a full paced natural step. A pontoon carriage and a trestle bridge carriage also passed. The cavalry horses looked rather stronger than those of the last corps we had seen. Cuirassiers in white uniforms with their cuirasses, a colour and an equipment that must have its disadvantages on service; but they looked well now, so did the dragoons with a good light blue uniform, without any nonsense about it, plain and well looking. The lancers with various facings, good uniform with serviceable horses; the hussars neat, good uniform, and handy horses, which would look all the better without the long pointed saddle cloth hanging low down on the horses' flank. The artillery horses looked in good order and condition after their being now for some time exercising and manœuvring. The equipment of all the horses of artillery and cavalry seems quite plain, little of show for polishing, &c. The guns have six horses, with similar arrangements to those of other corps for carrying the gunners: a pole is used, not shafts, long traces between the leaders; occasionally this space between the pairs of horses enables a leading pair having passed a swampy ditch, or obstacle, to get a firm footing to help the others in their difficulty.

September 14, 1869.—To the station for Heiligenbeil, a large village about 25 miles from Königsberg, where we found our horses ready for us. The principal portion of this the 1st Corps was drawn up on a plain south-east of Heiligenbeil; it had before it one of the small undulating water courses or valleys: a supposed enemy, marked by a few men, was beyond a similar but steeper-sided valley at some distance from, but parallel to, the other valley. On the order being given to advance, it was good to see from the enemy's side the whole spread out, first cavalry, then infantry columns appearing on the edge, and then crossing the first dip. On the plateau between two valleys the skirmishers met the enemy's outposts, which were of course driven in, though some farms and enclosures were supposed (by several attacks and retreats) to be contested properly. The attack on one part of this plain was made by 28 or 30 guns in battery to prepare the way for passing the main valley held by the enemy, and this was the bone of contention. Two small bridges were thrown over the broad ditch (for it was nothing more) which formed the water course. It was not actually impassable without bridges, but the cutting down the banks, &c., would have delayed troops, therefore only the baulks of the trestle bridges were laid across and floored. One of these giving passage to artillery and cavalry was laid in $3\frac{1}{2}$ minutes; but no trestles were used as trestles, the baulks were merely laid across, planked and secured. The infantry passed in close sections of fours at the double, carrying their firelocks with bayonets fixed at a sort of sloped advance: fortunately no man stumbled or fell, for surely many bayonet wounds would then have occurred. The batteries, heavy and light, came down a short but very steep pitch to the bridge, the poles went high into the air, the collars of the wheelers anywhere, a man held back the wheeler by the bridle, they got down without difficulty, and did not even use a drag rope. I saw two or three batteries pass in a similar manner. When the troops had formed for attack on the other side of the gully, I saw

a very good advance of three battalions (one regiment) in line, preceded by skirmishers, charging to attack with drums beating and men cheering. But it was ordered they were not to be successful here, the enemy advancing his thin line and forcing them back. But then this capital line formed column for the purpose of retiring, and under fire; and not long after, I saw a depth of several battalions remaining exposed in masses to the fire of the enemy's guns: this was, however, remarked upon as wrong, but there certainly seems a practice in manœuvres in peace of moving columns under fire. The troops marched as usual very well and steadily, and although there was no difference in principle as to the movements, yet it showed another complete corps of 20,000 men in readiness for service.

Thursday, September 16, 1869.—There was much conversation yesterday in the train between several Officers as to the different systems of fighting in line and in column. I was told that it was left somewhat optional with Officers commanding regiments (of three battalions): but the formation or movement of line seems but little used, except for skirmishers; the handiness and facility of commanding troops in column is tempting enough in peace to make its danger of formation under fire be forgotten.

A day having intervened since the last manœuvre, the corps was now divided into two opposing forces, which, as East and West Divisions, were to be opposed to each other near Braunsberg, a town on the River Passarge, which runs from south to north with a very winding course to the Frisches Haff and the Baltic. The county east of it has large woods, open and unfenced agricultural plâteaux, somewhat steeper water-courses, the soil deeper and stiffer than we had seen on former days, and the rain had made it on parts very heavy to move across.

The main force of a defending West Army was in position near the village of Schillwegen, with its strong outposts about one mile and a half in advance at other villages. An East Army was to advance from its position near Grünau, about two and a half or three miles from these outposts, drive them in, and force the enemy back towards the River Passarge. These general dispositions being laid down, separate orders were given to their own divisions by the two Generals, who named places of possible retreat, &c. About six miles of country in a direct line must have been passed over to-day by the East or attacking force. Early in the day, after the general advance, there was a cavalry engagement. The horse artillery and dragoons of the attack advanced through some deep meadow land, concealed by rising ground on their left, in order to get round the enemy's position: but the enemy from the rising ground brought down some lancer regiments and charged straight on their flank. They were caught; they formed up quickly, but not in time. All was well done, and with quickness of working. During the day I saw horse artillery come down one of the steep valleys and up the other side, a very sharp pitch, partly deep plough, partly irregular little grass gully, which twisted the gun and limber about seriously. This work was done very actively, the horses well whipped up on their flanks, not shoulders, one gun nearly stopped by the

depth of soil and steep pitch; but all got up and went on actively through the wet plough that took my horse above his fetlock at every step. There had been much rain during the night and through the morning; the ground was very heavy for horses, even at a walk, through plough and clover; the wheels and carriages of the artillery were covered with sticky mud, yet no troops could move more cheerily over it during a long and trying day. There was no difference from other days in the system of skirmishing and attack. Positions for bivouac were taken up for the night on both sides; they were well and regularly arranged. Some of the men did not get their food till quite dusk: ½ lb. of meat, rice, potatoes, and 1½ lbs. of bread is the ration. Quantities of straw and firewood were given, and the troops would have wanted it, for it rained hard at dark, and we had to return to the station at a foot's pace.

September 17, 1869.—Elbing. By train to the village of Bömerhofen, the same district as yesterday, but more to the south, and still on the right bank of the Passarge river. The West Division, driven towards the river yesterday, was to try by a counter attack to hold some strong ground at Klopeben Windmill, whilst the East Division was to continue its attempt to force the enemy over the river. A wood in the centre between the two divisions gave excellent practice for the advances and retreats on both sides. The fighting from the supposed circumstances of the day was closer, and for that reason showed much unreality, though much activity. Artillery certainly remained exposed at 500 or 600 yards to a constant fire of skirmishers; every horse must have been killed, and certainly the close columns of battalions, and even of regiments (three battalions each) were constantly within artillery fire. But again this day's manœuvre was a very good scene and practice for marching and arrangements across unknown country. A trestle bridge was thrown over the Passarge about two miles off; we found that it had been made by pioneer companies (engineers) over night. The stream was shallow, but swift, and was crossed by about 90 feet of bridge. I was told that it was thrown last night in the dark in half an hour, exclusive of the levelling of the banks. We saw a heavily laden country waggon pass over. Chains from the head of each trestle support a main baulk of timber; through each end of this strong baulk the upright trestle passes in a mortice, and a flat shoe prevents the heel sinking into the ground. Sets of trestles are joined by beams, on which the planks are laid, and another beam passes over the plank ends, which are fixed by the rope known as a Spanish windlass. It must be a strong, expeditiously-made bridge, but is said to require a boat. We rode back to see the advance and retreat of the troops. Much was done in close columns of advance and masses of column in retreat, but artillery not much brought up on either side. Where the road led through the wood to the bridge the defence was heavy enough to prevent further operations, and the troops took up their bivouac.

September 18, 1869.—From Elbing to Münchausen and to Fürstenau in a long string of carriages, partly by country roads of holes and mud. The names of companies and number of men quartered were

written up on the houses of villages; the country full of flax, which is twisted round short poles stuck in the ground, looking like large individual skirmishers in the fields. A country of very stiff clay and heavy ridges of plough, trying for horse and man. To-day the West Army had been supposed to be forced across the River Passarge to its left bank: the East Army was to advance to the river, cross it, and attack the West Army, which was to hold the line of the river. The East (attacking) Army crossed the river at the Plasswitz Mill and at the Ford of Rawusen, and the great fight was in a bend of the river at the village of Borchersdorf, the ground near which was a plateau with undulations of small relief, but sufficient to give command, particularly for artillery. From one of the projecting spurs in front of the village we looked over the lower ground and upon the infantry of the attack, assembled in columns within excellent range of artillery, which might have pounded them effectually for a quarter of an hour at about 1,000 yards distant. But the artillery was not much brought to the front. From the situation of the village in the bend of the river, the repeated attacks upon it and defence of it were closer and more concentrated than on other days. There were several cavalry movements and charges of great interest, all done with activity and apparent handiness of management, accompanied, however, by many impossibilities had it been war—infantry firing at each other standing still within 100 yards, and again movements in column under close fire of infantry and artillery. Several field batteries took up excellent positions for firing on the cavalry masses, and I saw a battalion in line firing well in three-deep formation, one rank kneeling, a very powerful means of infantry fire. The steady marching of the men was admirable over deep, dirty, and rough plough; they were always in hand, heard and well obeyed their Officers, and indeed are capital marchers,—scarcely any were falling out in these long days, beginning at early morning and from a night bivouac. They march in boots over their trousers, are covered with mud, but do not look tired, though carrying their packs, great coats, haversack, with bread, water bottle, &c. After yesterday's bivouac in mud and rain, the men and horses and guns were turned out comparatively clean this morning, evidently making the best of an uncomfortable night's lodging in the fields. This being the close of the manœuvres for the year, kind words were said by His Majesty the King of Prussia to many foreign Officers, and some were thus enabled to thank His Majesty in the name of their brother Officers for the gracious and kind hospitality given to them during a period of three weeks.

Remarks have been made in these notes on the formation and movement of columns when supposed to be under fire; these observations are not made in any mere spirit of criticism or objection. The subject was one of discussion between English Officers amongst themselves, as well as with foreign Officers, in amicable and open conversation. Different nations have different systems, suited probably to their different organization and to their national character. The subject is important equally to those liable to command as to be commanded. It is in the recollection of the authority and practice of great English Commanders

in successful battle, that the system has been referred to which is a contrast to our traditional mode of fighting.

MANŒUVRES AT HOME.

Notes made in October, 1871, on the Home Manœuvres of September, near Aldershot.

Control.—With regard to the Control Department, an Army is no real Army unless it can move; it cannot move without its supplies of ammunition, food, and stores being near at hand, moved and controlled by the General Officers in command. The title of this department seems an anomaly. Control—what does the term mean? Control of what, or of whom? of the supplies and transport, or of the General or other Officers? The name might well be restored—for it would be better understood—of Commissariat, with enlarged duties; for it was a well-known corps identified with the Army, its movement, and supplies; or named "Army Service Corps," which would also be an appropriate general term for the duties it has to perform.

The contrast between the number—about 1,000 horses—provided in the Army Estimates for the Military Train of the whole Army, and the large additional number by which these were supplemented for a few days' manœuvres carried on from the Aldershot centre, is very instructive. The extra purchase of 800 horses, the services of spare artillery horses and men and of cavalry horses and men, besides civil transport hired in large numbers, all show the present inadequacy of this essential portion of a military establishment. And this large addition was merely to feed, and to move from and round a limited central point, only about 30,000 men and 2,000 horses.

The permanent establishment is not enough to form an efficient nucleus; it could scarcely move a division of 6,000 rank and file, including two batteries of artillery, a march of fifty miles away from its base with three days' provisions and stores.

The organization of such a corps is both difficult and expensive, but necessary. At present it has too much the idea of a cavalry corps, and would be better for more simple duties, dress and equipment appropriate to their main purpose, which is not fighting or manœuvring or drilling, but the attentive care of their horses and safe movement of stores. Debarred by their position from the motives, and possibly the distinctions and rewards of other soldiers, well-selected men should be secured, as in foreign Armies, by superior pay, so that stores valuable to an Army and its detachments should with confidence be entrusted to even a single driver detached from his corps.

It would be advantageous to the Army if those answerable for the efficiency of this corps were to see the transport even of a division assembling for its march at daylight from a peaceable camp; it is then seen how necessary is its previous organization and discipline.

The bell tent should be of linen canvas, the white cotton lets heavy rain through in a fine mist; but the new *pattern* of the cotton tent, with its shorter pole and considerably higher wall, is superior. It

would tend to preserve the tents, and be a relief, if they were of a light tan colour.

The meat ration was during the manœuvres the usual three-quarters of a pound, including bone; the work in these marches and movements, with the time the men are under arms, fully justifies, I might say necessitates, a ration of one pound; the "soup and bouilli" in tin cases is objectionable, from the absence of sufficient solid food.

The steam ovens for bread baking would scarcely be practicable on service, except upon good roads, and in tolerably fixed stations in rear of an army: in these late camps carts or waggons of coke were attendant upon them. The sheet-iron field oven covered with earth is more practical, though its good baking is uncertain in wet ground.

Cavalry.—There was evident power, and good stamp for their purpose, in the horses of the Army. There will be competent opinions given as to the cavalry, the details of picketing, and other arrangements, as well as the general employment of this arm, during these manœuvres.

I do not understand why light cavalry should be in blue and heavy cavalry in red, nor why any cavalry should wear trousers over boots instead of boots over trousers, nor why they should ever wear a fixed spur, which is inconvenient and dangerous to man and horse in case of accident, and which no one uses in real riding. One regiment need not be exactly like another; on the contrary, it is advantageous to know them at some distance; but the colour of the uniform should be distinct. Light cavalry is not unfitted for its purpose by a red coat; and the darker the colour, whether of infantry or cavalry, the more distinctly is it seen at break of day, in evening light, and on the sky line.

Artillery.—It is a pleasure to see that in almost every detail of artillery for the field there is a service-like simplicity, and the absence of mere ornament on guns, carriages, and harness, which shows all being made for strength and utility. A service so efficient can, without offence, bear criticism.

It would seem that for laying a gun with accuracy, as well as firing a rifle, a shade for the eyes is necessary; yet we see an ornamental head-dress without any cover for the eyes; foreign nations apparently take a more common-sense view of this subject.

It is not service-like for artillery to carry tents upon their ammunition waggons; these are intended to carry near to their guns shot, shell, and powder, not baggage. Tents are baggage, and look like it; each first line waggon has now an extra load of nearly 2 cwt. of positive baggage, which should be replaced by ammunition, if such extra weight can be carried. Tents should be in charge of the Transport Corps; nor is it necessary, as was seen on war service in 1854, for the subaltern of artillery to have a tent when the General of Division slept in the open.

A field battery must be moveable, with fair rapidity, and with ease to those who are to work its guns. It is absurd for a field battery (as I have frequently seen, and lately accompanied) to gallop, with its guns and limbers, for more than a mile to defend a position, and arrive

with two gunners to each gun: Three gunners on the limber, two more (and surely it is not necessary for all the detachment to be large men) on the gun axle seats; this has been shown in war to be perfectly practicable, and must be adopted if artillery is to "hold its own."

Reserve artillery, for a General to use on special occasions, should be horse artillery; its use need not be confined to accompanying cavalry when rapidity for other purposes may be essential.

There seems a disposition to enjoin upon artillery to take an independent part under its own officers: the late General Memorandum of September 17th does not entirely admit this view, and it is to be hoped that the discretion proposed to be given to artillery, and the subordination of its movements, will be observed; otherwise the Captain of a battery and the General Officer had better change places.

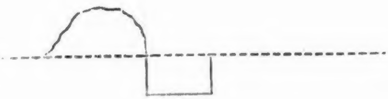
The firing of shell, and even of shot, at an enemy over the heads of infantry, unless the guns have considerable command, is convenient for artillery, but a questionable practice as concerns the infantry fired over. Sound of shot overhead is apt to distract in action, whether from enemy or friend; and one shell from a friend in rear bursting short may almost disorganise a battalion in its advance under fire. Possibly shell, at high elevation with low charges and great range, if practicable from field artillery, would be safe over our own advance, and very damaging to an enemy. There are few things more difficult to avoid, or more dangerously disagreeable to troops, than the sound and arrival among them of mortar shell.

Engineer.—The engineer trains for telegraphing, for pontooning, and for the carriage of working tools for themselves, and those on pack horses for the general service of infantry, seem well arranged for their purpose, and are essential to an army. There are subdivisions or sections which can be detached with all sorts of implements for strengthening outposts, or passing obstacles, and the pack horse arrangement is good for infantry purposes.

I do not know whether late wars on the Continent have shown the power of the telegraph for orders in the immediate presence of the enemy. This may be doubted; but there is no doubt of its practical utility and ease of placing on main lines of operation. The French wire cylinders are made narrow, to be placed on a pack animal, and the wire laid down from it if necessary.

In the Hanoverian manœuvres of 1857 I saw a trestle bridge which accompanied the troops, and which was thrown quickly during the manœuvre over a deep but narrow canal or water course which stopped the march. Field artillery passed over it: it might be worth the attention of engineers, as simple and effective.

If the trenches made at Chobham were "shelter trenches" for a temporary purpose, they had better not be formed with perpendicular sides; an enemy getting possession, could use them at once for cover. They, as well as rifle pits, should be sloped at a very small angle, thus:—

Instead of 

There would be the same amount of cover on one side, but none for an enemy; and it gives much less obstruction to the movements of one's own troops of all arms when necessary.

Infantry.—If infantry is to be called upon to march and then to fight with activity and with ease, the knapsack must either be reduced in size and weight to the barest necessity, or it must be carried by transport. It is the weight that kills and makes casualties, and the marching and fighting qualities of the soldier must not be sacrificed to anything.

Rain is the great evil to the camp, the bivouac, and the march; the equipment for service in 1856 was the great coat, to be only folded into the sleeve without any pins or fastening; under its straps was to be carried a thin sheet of india-rubber material, 6 feet by 2 feet, with eyelet holes. This could easily be put over the shoulders on a march, and be useful for other purposes. At present the great coat is pressed into shape and fastened with so much trouble and nicety, that care is taken not to use it. It should not be of thick, heavy, or spongy material, for the soldier has to carry it dry or wet; but the small waterproof above mentioned would keep it dry on a march.

The present half boot is neither a boot nor a shoe: if a boot, it should be the laced boot, the usual wear of the peasantry of England, to fit close just above the ankle in order to keep out dirt, and be supplemented by a close fitting legging from the ankle to below the knee, thus taking the weight of the trouser off the knee in marching, a practice universally observed by those who work hard. What has become of the old light infantry knee-pad? It surely might be useful with the present rifle position of the soldier, whose trousers seem now to be made tight where they should be loose, and loose where they should be tight. He would be a benefactor to the soldier who would make his dress easy and fit for hard work, and who would invent a fairly waterproof, but soft and substantial head-dress or helmet which would fit like a hat, and which he would not be tempted to get rid of on service in order to wear his forage cap.

A soda-water bottle, hanging by its neck and dangling about, is not a good arrangement for the soldier; it is heavy in itself, and holds a very small quantity: it had better be of tin, well soldered in the inside to prevent rust, its shape rounded out to fit the side; it should have a large mouth with a cork bung, over which should fit a small cup. I

have seen this in a foreign army; the strap should be broad, and go round the bottom of the bottle to bear its weight and keep it steady.

The colour of the infantry coat is bad, and discreditable; it is well termed "brick dust," and its appearance kept up this character at the final march past of the corps at Aldershot on the 22nd ult. It deserves its technical name after short wear, from showing the white cloth underneath the worn-off scarlet surface; for this cloth, made up white, is dyed in the piece, not in the wool. Far better would it be to give up such attempts for bad scarlet, and adopt a real good bright red, such as the French or Turkey red. This is dyed in the woollen yarn before it is wove into cloth; the colour remains good, being in the grain, and is far superior to an attempted scarlet, which soon shows its inferiority by wear.

With very few exceptions English fighting troops of all arms should have red coats; distinction from an enemy is of importance. There have been many instances of fatal mistakes; even lately at Sedan Bavarian infantry was seen to be shelled out of the village at Balan, by Prussian artillery firing from the opposite side of the Meuse, at about 2,000 yards distance.

There were instances of the ammunition carts and regimental colours, when in camp, being given in charge of the quarter-guard in front of the battalion towards the enemy. The quarter-guard is not for this purpose; the front of a battalion camp should be kept entirely clear or assembly. The quarter-guard is the means of communication and alarm to the battalion from its outlying picquets, and its sentries should be in communication by sight and signal for re-inforcement to the outposts, or to get the battalion quickly under arms. The colours should be at the tent of the commanding Officer; the ammunition in rear of the battalion.

In most cases the skirmishing of the troops under my observation was fairly done where the country admitted; men advancing short distances rapidly to cover, remaining there firing, and then running to other cover; in other cases there was slow exposure in advance and retreat, and a tendency to collect together; this bad habit requires correction, for the proper occupation of cover by skirmishers should become an instinct by enforced practice in peace. Every one must have rejoiced at the absence of bugling; there is no greater source of mistake and confusion than perpetual company and battalion bugling in the field. It would almost be good for the mouthpieces of bugles to be taken possession of by an Officer or a sergeant when in presence of the enemy.

It is right for the large cooking tins to be carried by transport, and not by every sixth man. They are cumbersome to carry; they are got rid of frequently, and casualties to men render many of them not forthcoming. But there should be occasional practice of halting and quick cooking in the small mess tins during a march; if the ration of meat were one pound, which it should be, half of it and of the bread should be carried and cooked occasionally in the march by the soldier; the other half to be cooked in the large tins on camping.

It is unnecessary and disadvantageous for an ambulance waggon

with two horses to be as close up with a battalion as its spare ammunition. Even on Hartford Bridge flats the jolting and jerking would almost have broken the limb of a sound man, and certainly could not have been borne by a wounded man. Wounded men should be carried from the field by hospital men with stretchers. whose special duty it is, and thus, as in other armies, prevent any soldier quitting the fighting ranks. The ambulance waggon or cart to be used mainly to convey wounded to the division or other hospital.

It is to be hoped that there will be no tendency to diminish the steadiness, the solidity, and the military regard due to English infantry. It is the first arm of the service, the only one really self-dependent in action; it is the main strength of all armies; to which cavalry and artillery are but accessories, notwithstanding their power. The infantry should be the senior, the preceding service in line and in parades, as it is the most important in war. It is so placed in other armies than that of England; and the spectacle is not seen of clouds of dust raised, and of ground cut up by cavalry and artillery, for infantry to march past upon in their track.

I do not think that the steadiness of movement or real rapidity of formation of infantry has of late years been maintained. I was in command of a battalion at Chobham Camp, in 1853. Lord Seaton counselled and ordered the loosening of *files* for ease of movement on such ground, but he did not order or counsel looseness of manœuvre or formation.

I speak of the steady movement of infantry, and particularly of English infantry as a quality to be valued, and it has been valued by our enemies as well as allies; quickness and "doubling up" in manœuvres may be pretty theories, good sometimes for parade show, or perhaps occasionally necessary; but it is the duty of Officers to husband the strength and wind of the soldier, who carries 60 rounds of ball cartridge, his knapsack, his water bottle, and his haversack of provisions on service.

Some late alterations in drill, and even words of command, have not added to the steadiness or compactness of infantry for the purposes of war. For instance, the increased distance of 30 paces ordered between battalions; the formation of line, the special fighting formation of English infantry, is for the purpose of advancing to close attack, or to give close fire; but I have seen with well drilled battalions in Hyde Park those 30 paces become 70; and I have seen in the late preliminary manœuvres those 30 paces extend to 100 between battalions; necessitating the unsteadying of a line and great loss of time, in moving battalions in brigade by fours to their right or left. If the reason of this increased space, and consequent weakness, is to admit the passage of other arms, is it not still practicable to wheel companies? The front of brigades and battalions is more likely to be diminished on service than increased; a skirmishing company ordered from a battalion, a skirmishing battalion from a brigade or division, makes a gap, and killed and wounded make gaps; there is no necessity for increasing unavoidable spaces, which diminish the power of fire, which may enable

the enemy to take advantage of a weak point, and to mark the strength of opposing battalions to a nicety.

The more frequent orders than formerly to change the dressing or directing pivot of a battalion, is another source of unsteady movement, producing a shifting and swaying of the men, and an uncertainty of direction, frequently at the wrong moment.

A good, distinct, and easily understood word of command was lost to the Army when the "Right or left shoulders forward," with its clear sound and caution, was replaced by the word "wheel," with scarcely any caution; nor is the word "half battalion, half company," an advantage over "wing" and "subdivision." I have more than once seen a whole battalion mistake the word of command to itself of "half bat- "talion" being given to a wing for another purpose.

The small arm ammunition carts for each battalion, drawn by two horses, kept up fairly, but they had only blank cartridge. I did not observe any cradle or pack saddle for putting boxes on horses to supply places not accessible to wheels. There is in writing the strongest opinion by the late Lord Hardinge that the first reserve of infantry ammunition should be on pack animals, so as to be with a battalion in any position, and not impede the line of march by wheeled carriage. There was an arrangement for a Maltese cart with mules, and spare mules, in 1856, which might be worth attention.

It may be advantageous to be able to use a portion of a battalion for a special purpose without diminishing its fighting front. One foreign army forms its infantry in three ranks for this purpose, taking the third rank for its skirmishing attack. A battalion of ten companies might have the following formation:—Two companies as active marksmen, to be one in rear of each outer company of the battalion, the flanks of which would thus be strengthened for defence or for sudden advance, or for the occupation of points of importance, without diminishing the front of the line and its efficient fire; these two companies might add their fire over that of the ranks in front of them when kneeling.

The long rifle with a short and light bayonet should not be given up for the general infantry: it ensures safety to the front rank when firing in two ranks, which the short rifle does not. The weapon, whether rifle or bayonet, had better be kept intact for its main purpose—fighting: its efficiency should not be risked by its use as a saw or a chopper. Axes and bill-hooks are now carried in a cart close up to a battalion: every soldier should have his own clasp knife, and have no excuse for any other use of his rifle and bayonet than for its proper purpose.

I will not omit referring to the recommendation and practice that squares should be formed two deep. Any one placing himself at 1,500 or 2,000 yards from the battalion in square, will see how much more extensive a target for artillery is the two deep than the four-deep square: it is double the extent of front; it takes twice the time to form; is weaker when formed, and gives no additional fire. If the accounts of cavalry Officers in war are reliable, it seems that the tendency of cavalry under fire of a square, is to open out and pass the square: this tendency is helped by the concentrated fire of a smaller rather than a larger square. Cavalry will scarcely charge direct upon

a front of infantry in position; but fog, concealment by ground, or smoke in battle, may give the opportunity of sudden or flank attack, when the rapid and substantial formation of square should be instinctive in every company of a battalion: in the midst of noise, smoke, and fighting there must be no uncertainty as to what sort of square is to be formed. Our English 4-deep square has long stood the practical test of war; its steady formation and resistance has been proverbial, and should scarcely be subjected to experiment.

In the narrower or parish roads the whole space was frequently occupied by the troops on their march, preventing easy and necessary communication of orders; the front of infantry in fours, with an Officer or Non-commissioned Officer besides, is too great except on turnpike roads. This communication of orders is of importance: the passage of mounted Officers and orderlies should be along the pivot flank, the reverse flank being close on the outer edge of the road. This should be an essential observance in route marching at all times, and staff and other mounted Officers should be cautious never to alter this regimental formation when passing with orders.

It might be advantageous for the General Officer commanding, and the staff and departments of each division, to have a distinctive pennon, colour, or badge. The mounted orderly of a French General carries his particular pennon, which is seen and known, and a coloured badge fixed temporarily on the arm might be suitable for others.

I do not refer to the main strategical movements of the troops. The general outline must, almost necessarily in England, be settled beforehand, rather reversing the practice of war; and unless the transport service is complete, disciplined, and under the orders of the General Officer, "strategy" must be subservient to a previously arranged delivery of food and fuel.

It is my impression that the daily movements extended over too great a space. The flank marches and proceedings distant from the sight of the enemy may have been practice for the two or three superior General Officers and their staff; but if the movements are to be of utility and military interest to Commanding Officers of battalions, to the Officers of their corps, and to the soldier generally, they should be more concentrated,—rather tactical than strategical,—so as to give Commanding Officers of battalions, their Officers and men a better insight into their duties of attack and defence on ground where a Brigade-General can have his troops under his own eye, and where the troops themselves can see how they support each other in attack, in defence, or retreat. To take the experience of one of the brigades composed of seven battalions—too large a number for a brigade-command—during some of the four days of supposed war movements: the principal occupation of most of these battalions was to march for hours between two hedges along a dusty road, sometimes beginning their contact with the enemy by each firing at the other along an open road from not being allowed to occupy enclosed land on each side. On one of these days a whole division of thirteen battalions only came in sight and contact of the enemy, after a march mainly along enclosed roads of about seven miles; the position of the Hog's Back on the east, to

Beacon Hill on the west, was an extent of about eight miles, and the troops in supposed occupation of it (exclusive of cavalry and artillery) amounted to less than 7,000 rank and file, including a skeleton force derived from Aldershot for the morning. I only refer to this extension of the troops to show that greater concentration of defence and attack would give more practical interest to those employed. Nor can it be forgotten that such extended lines have an element of weakness, and are scarcely consonant with war practice.

The advance of 50,000 men to attack the position of the Alma covered scarcely three miles frontage of the ground; and the movements for the battle of Vionville and Gravelotte, with 230,000 men on one side and 170,000 on the other, extending even to the bridge of Pont à Mousson on the Moselle to the south, did not extend over a greater space than fifteen English miles from Metz, and less than that distance to the west of it.

I submit that professional advantage would accrue to the body of the troops employed, by their movements being confined to a smaller daily area than in the late movements near Aldershot.

Referring to matters of mere parade, when troops are in line or line of columns, the fewer mounted Officers there are in front the better the troops are seen. In marching past, the General Officer should be the leader in his own person of his Division or brigade, closely followed by his Staff in one line; and as these latter Officers do not draw their swords, they had better not salute at all, than do so with their right elbows towards the saluting point on their right.

In all the camping and simulation of war service there should be no omission of the traditional practice and precaution of the English Army, for all troops to get under arms an hour before daylight every morning when in presence of the enemy. This should be a habit even in peace manœuvres—the men to remain in their tents with their arms if the weather is bad, until safe information comes from the front.

In bringing these remarks to a close, let us remember that all peace manœuvres are but to secure a readiness for war; and that amidst the theories, the maps, and speculations, fighting, hard fighting, will remain one great element of success.

Terms of depreciation are now used of "English lines standing up "to be shot at," of the "antiquated way of fighting in line:" but history and the practice of our great Commander shame these expressions, and show that the English formation of line has always overcome the more antiquated formation of column.

Troops in line give most fire, have most individual power, and suffer least exposure either in attack or defence. The range and accuracy of artillery ought to overwhelm troops in column; and the experience of some attacks in the late war in France confirmed to those engaged, as it might well confirm to us, the danger of such formation under fire. Attacks by skirmishers are surely no new invention, but they never succeeded, by themselves, in taking a position solidly defended.

Of those hereafter in command, from the subaltern to the General, there will be required anxious thought and perhaps sudden decision, on the best means of bringing men, either in attack or defence, to the decisive closing point with the least loss of life; and attention may well be given to the suggestions or practice resulting from experience, and adopted whilst fighting was going on during the war of 1870.

I refer to the dispersion of troops in open order to commence fighting, and to their subsequent concentration *in advance* for that closer order of attack by which alone success is secured.

To overcome difficulties, to require bravery, exposure, and self-denial, mutual confidence between Officers and men is essential; similar confidence between man and man of the same company, and the same battalion, is equally essential, and we of the English Army have long felt pride in this security. It is not the growth of a day: it depends on time, habit, and tradition, as well as command; it forms the best part of our regimental system, by engaging each individual in the well-being and honour of his corps.

That nothing may break that confidence between man and man, or mar the gentlemanlike—as well as the military—confidence between Officer and Officer, that the existence of a battalion with its tradition and *esprit de corps*—the result of slow but strong growth—may not take the form of a passing and disjointed assembly of recruits, must be the hope of all who know the Army and have at heart its permanent welfare.

The Chairman: As Vice-Chairman of the Council I have to thank you, Sir William, for the paper you have read. I fully expected when you did us the honour to consent to give a lecture here, that from the opportunities you have had of making observations both at home and abroad, it would be of a practical character. I may say that that expectation has been fully realised. The lecture, moreover, is calculated to give rise to much thought, and to the consideration of the many useful and practical points of detail which it contains.

Evening Meeting.

Monday, June 24th, 1872.

General J. R. CRAUFURD, in the Chair.

NAMES of MEMBERS who joined the Institution between the 18th and 24th June.

LIFE.

Pratt, S. C., Lieut. Royal Artillery.
Clerk, Godfrey, Lt.-Col. Rifle Brigade.

ANNUAL.

Cologan, J. Fitzgerald F., Captain 18th Bengal Native Infantry.
Bland, T. E., Lt. 5th West York Mil.
Gibbs, John, Lt. 5th West York Mil.
Bunbury, Charles T., Capt. Rifle Brig.
Acland, C. T. Dyke, Lieut. 1st Devon Rifle Volunteers.

ON THE LATEST CHANGES MADE BY THE PRUSSIANS IN THEIR INFANTRY DRILL-BOOK.

By Major E. M. Jones, 20th Regiment.

The Chairman: Major Jones, who is about to read us a paper on "The Latest Changes in the Prussian Infantry Drill-Book," is particularly qualified to undertake that task, having formerly served for three years in the Prussian Guard. Before he begins his lecture I will—just as an introduction—read a translation of a short preface to the new edition of the Prussian Infantry Drill. It runs thus:—"I hereby approve of the following reprint of the Regu-" lations for Infantry Drill, which contains the alterations directed by " me, and I order that what is appointed by it shall alone henceforth " have authority. At the same time, I repeat that which was declared " as his pleasure by my brother resting in God, King William Frederick " the Fourth, under the date of February 25th, 1847, to this effect— " that the discretion left by the regulationary directions for the forma-" tion and application of the troops, shall not be contracted without a " stringent cause, as what is merely formal might thereby take pre-" cedence of what is essential." I thought this preface so characteristic of the whole spirit of the new Prussian infantry drill, that it was desirable to read it before calling on the lecturer to proceed with his paper.

Major Jones: The first thing that strikes one on taking up the new edition of the Prussian Infantry Drill-Book is, how little it seems to differ

from the old one. The alterations are contained within the compass of a moderate sized pocket-book in Colonel Newdigate's translation, and only cover some thirty pages in Lieutenant von Biberstein's pamphlet "Was Enthält das neue Reglement." The general arrangement is the same; the headings of chapters and sections are scarcely altered; a few forms have been dropped; some improvements introduced; the "general "remarks" rewritten and enlarged; and that is about all. There is no startling or sensational change, such as might perhaps have been expected considering all that has happened in the military world since 1847, the date of the last edition, and the numerous works on Tactics which we owe to Germany. Those works give abundant evidence of the energetic and progressive spirit which animates the Prussian Army, and which led Baron Stoffel to use such expressions in regard to it as "Avide de progrès;" "on dirait d'une ruche d'abeilles," &c. Opinions are free, and thought is encouraged; any one who has a suggestion to offer, or a reform to propose, is sure to find an attentive audience, an unprejudiced tribunal, and, if his work will bear proof, proportionate acknowledgment. But it must stand the proof, and the same rigorous practical test is applied to all. For instance, the "Vortreffen," or advanced line was referred to twelve years ago by Prince Frederic Charles, in his well known brochure "How to Fight the French," as a tactical formation which had been recommended to him on the highest authority, and tested on the drill-ground with success. Yet it s only now officially adopted in the new drill-book, after having been extensively employed in the late war. The higher ranks in the Prussian Army may seem sometimes to be simply conservative; even here, in England, we have heard it hinted that the talented author of the "Taktische Rückblicke," was not appreciated in his own service as he deserved. It may be doubted if we in this country are altogether qualified, even if we are called upon, to pronounce an opinion on the subject. My own impression is, that in the higher circles as elsewhere in Prussia there is a keen desire for progress; only it must be *well considered* progress. Over-eagerness and indolence are alike discouraged, and the standard aimed at is a happy blending of great mental activity with studied calmness of judgment. It would not be easy to illustrate the way in which the path of reform is followed up in Prussia better than Baron Stoffel has done in his report of 22 July, 1868 (p. 191):

"Depuis deux ans, il s'est fait ici, sous le seul rapport des perfec- "tionnements à apporter dans les différents services, un travail con- "sidérable, travail opéré sans bruit, sans ostentation, mais avec beau- "coup de réflexion et d'esprit de suite. Au ministère de la guerre, "aux états-majors des corps d'armée, dans les diverses armes ou ad- "ministrations, fonctionnent des commissions composées d'officiers "ayant fait la guerre, qui étudient toutes choses, en vue de profiter de "l'expérience acquise en 1866."

The new edition of the drill-book resulted from the labours of one of these commissions and, in the first instance, exclusively from the experiences gained in 1864 and 1866. It was just ready for promulgation when the war with France broke out, the Royal Order by which it is prefaced being dated 3rd August, 1870. It was not, how-

ever, promulgated for another year. There would be obvious objections to the introduction of changes in drill during the progress of a serious war, objections which would perhaps be more strongly felt in Prussia than elsewhere. The new regulations were accordingly kept back until some months after the conclusion of peace, and then given to the Army almost, if not absolutely, without modification.

It may be assumed, then, that the new edition embodies all the changes which were necessary in order to bring the system of drill into harmony with the spirit and tendency of the *latest* Prussian tactics; if further changes be in contemplation, they cannot be vital, and are probably such as leave room for difference of opinion. We may be assured, moreover, that they have not been evolved, like the celebrated camel, out of the inner consciousness of a military philosopher, but have grown out of the practical experience of recent wars, and been matured by the keen thought and patient judgment of tried soldiers. All this makes it more than ever matter of regret that the treatment of the subject here did not fall into the abler hands to which it properly belongs, and for which it was originally destined, but I may perhaps hope that the imperfect remarks which follow may lead to a fruitful discussion by Officers of wider experience and greater authority than myself.

And first, to allude to the movements which have disappeared altogether from the drill-book as obsolete or superfluous. The principal of these are the "Achs-Schwenkung," or change of front of a battalion on its centre; and the "Aufmarsch der geöffneten Colonne," or formations of line from column at wheeling distance. The former was only retained in the old regulations as an "exercise for the drill-ground intended to make men and officers handy," and is now omitted altogether. On the other hand, the old form of deployment on a rear-division (Zug) "aus der Tiefe," is retained, though with an accompanying caution that the inversion of the divisions in a battalion should not make any difference.

The tendency would appear to be, while rejecting all such movements as would certainly be out of place before an enemy, to keep those which might by possibility be of occasional use. It is not, I believe, that the Prussians have grown indifferent to the value of mere drill movements, of evolutions which answer no purpose, and are intended to answer no purpose but that of making Officers and men handy; on the contrary, the proverbial strictness of their drill is as great as ever, and many of those present have doubtless noticed within the last year that the old exact attention to minute detail is still required from Officers and men. This strictness is indeed a symptom only, but it is a very suggestive one, and indicates the great importance which is attached to the careful, thorough training of the soldier. But it would seem to be felt that training must be carried a step further than it used to be. It is no longer enough that Officers and men shall be competent to execute with perfect precision movements rigidly defined by regulation; the Officers must now be prepared to direct movements for which words of command are not prescribed, and the men to

carry them out without previous practice. So, for instance, section 53, chapter X, refers, as in the old edition, to change of front in line without inversion, and indicates the methods by which it may be effected, but without laying down any precise form or word of command.

Another class of alterations includes those which represent the modification or fuller development of a tactical principle. Such are, for instance, the changes in the rifle exercises which are not due simply to the adoption of the needle-gun. Among these are the more definite and practical instructions laid down for aiming and firing; the substitution of "quick" for "file" fire; the increased distances at which firing is allowed, and the introduction of volleys in four ranks, the two front ranks kneeling. They all tend in the same direction, and aim at increasing the effect of infantry fire. Not that this is by any means a new feature in Prussian tactics. It dates at least from Frederic the Great. But now as before, and now more than ever, the object of their drill regulations has been to train the men to cool, accurate, and concentrated fire at effective range.*

Under the same head may be classed a modification which has been made in chapter II, section 16; according to which divisions (Züge) of *sixteen* files and upwards, not *twenty* as previously, are to be told off in half divisions. The object is to get greater flexibility, and columns of smaller front, which can be more easily placed under cover.

The last change to which I shall allude under this head is contained in Part III, chapter X, section 55 (56 of the old edition), and directs the formation of the skirmishing divisions each in rear of its own company, instead of taking post, as formerly, behind the flanks of the battalion. It is probably the most important in the book, representing as it does the victory of a principle which has been growing and gaining strength in the Prussian Army, more especially since 1866, and which meets us at every turn in the best tactical works, I mean that of keeping their tactical units down to the very smallest, as far as possible, unbroken and unmixed.† It aims at referring the men of each company and of each section even, always in the first instance to their own section and company for support, each company to its own battalion, each battalion to its own regiment, and so on.

Under the old system, the formation of the skirmishing divisions was the signal for a partial disorganisation of the battalion. The picked men, who formed the third rank, were taken away from their companies, and the command of the skirmishers of the whole battalion was made over to one of the four Captains selected for the purpose. His company was thus deprived of its leader just when the moment for action arrived, and he was placed in charge of a number of men dispersed as skirmishers, most of whom in all probability belonged to other companies. *Now*, each company will remain together under the com-

* Compare "Verordnungen über die Ausbildung der Truppen für den Felddienst und über die grösseren Truppenübungen," p. 109.

† See page 160, where the principle is laid down in so many words.

mand of its own Captain and the guidance of its own Officers, and each will, as a rule, support its own skirmishers, and will act, under all circumstances, as one organic whole.

An incidental advantage of the change appears in the formation of company columns from the column of attack (or double column as it used to be called) and *vice versâ*. Under the old system, when the skirmishing divisions were formed in front or rear, or partly in front and partly in rear, of the double column, a certain amount of time and movement was entailed in forming company columns. This is avoided now; the column of attack, with skirmishing divisions formed, being to all intents and purposes nothing more than the four company columns massed on a front of two divisions and brought under the immediate direction of the battalion commander.

The gain in point of simplicity and directness of control is obvious; nor is it attained by any sacrifice of real efficiency. The old distinction between the third rank and the others, according to which the men in the former were destined exclusively for skirmishing and the latter for fighting in close formation, has been abolished, and all ranks alike are now to be employed in either way, though the third rank will still be composed of men especially selected for the duty of skirmishing.

Another minor result of the change is that a slight increase of interior space in square is obtained. The preference for the solid square still appears to exist, though we may perhaps see the thin end of the wedge introduced in the new method of forming company square (chapter IX, section 42) by which one, the third, half-division wheels outwards to form the sides of the square. It is true that the well-founded objection to the use of the solid square which lies in its limited front of fire has lost some of its force in these days of breech-loaders.

The change which we have been considering, and the larger and more effective application of company columns, which is intimately connected with it, may throw some light on the retention of three ranks in the Prussian regiments. It may have seemed probable to many of us, that the formation would be abolished and that all the infantry would in future be formed in two ranks as is the case elsewhere and even in their own rifle battalions. There were in fact, I believe, many advocates for the change, and it seems, *primâ facie*, a needless complication to have one formation up to the moment when fighting is to begin, and another for the action itself. But there will appear on consideration, a good deal to be said on the other side, at least from a Prussian point of view; and we may imagine the supporters of the old system to have argued something in this way: "We need say nothing about the greater solidity which is possessed by a line three deep, because we do not contemplate any extensive use of that formation in the field. Practically all or nearly all our fighting is done in company columns, and we use two ranks when it is desirable and three when they are in place. The only objection to the practice which we are concerned to meet, is that the change from 3 to 2 ranks, on assuming formation for action (Gefechtsformation) is mischievous. The arguments against it appear to us more specious than sound, and to spring from a wish for theoretical uniformity rather than from any

proved inconvenience. It can hardly be seriously maintained that the manœuvre implies or actually produces confusion or appreciable loss of time. If it be contended that the practice is not absolutely mischievous, but only unnecessary, we reply that it gives us two or three distinct advantages which we are not anxious to part with. In the first place, it shortens the line and therefore the depth of the column on the march. It also enables us to keep our best skirmishers distinct from, but close in rear of, the other two ranks, and gives us the power of using them in extended order, without causing confusion or diminishing the extent of front, and of placing our hands at once on the men we want, if a few well-aimed shots are to be fired at long range. We do not believe that these advantages can be obtained in any other way to the same extent and with so little drawback; and, unless some positive gain is in undoubted prospect, we consider that we had better hold fast to a system to which the Army is accustomed and under which it has so far got on pretty well."

Whatever the arguments were, they have prevailed, and for the present at least, the Prussian Infantry regiments will continue to be formed three deep until they go into action.

The largest amount of modification is to be found in the sections of "general remarks," and in the chapters of Parts IV and V, which treat of the "battalion in action," and of the "brigade." Naturally we have not to do here with definite omissions or alterations; but, as these chapters really indicate the difference which exists between the views held by Prussian tacticians 25 years ago, and in the present case I propose to offer a condensed abstract of them compared with the corresponding ones of 1847; referring those who wish to examine more closely into the matter to Colonel Newdigate's translation.

Chapter XVII, sections 100—108 of the new, corresponding to sections 108–116 of the old edition, introduces minor modifications only, the most prominent of which are as follows: in a long line of skirmishers, detachments or patroles must be held together to support or secure the flanks: skirmishers charging, are to close *in* the enemy's position under direction of their Officers: a line of skirmishers is, as a rule, to be reinforced by prolonging it; in any case, the men of the reinforcing party must be kept together, the old skirmishers reducing their intervals so as to leave a sufficient space for it: closer supervision and control of the men's fire is demanded from Officers and Non-Commissioned Officers.

In chapter XVIII, the introductory section strikes the key note of the whole, by insisting on the importance which attaches to the action of skirmishers in the present day, and on the fact that "the possibility of "concentrating their fire in respect of time and place gives them a power "of *offensive* action, which may under favourable circumstances be, by "itself, decisive." It is a rule, therefore, in regard to the application of infantry fire, that it should be concentrated on the most important point for short periods of time. The enormous strength which is thus secured in front, brings out more than formerly the importance of the flanks in attack and in defence. The ideas here indicated, are worked

out more fully in the succeeding sections; more especially in those numbered 113–115, which have been entirely re-written in the spirit of the latest Prussian tactics.

Sections 120–121 of the old, like 112–113 of the new edition, speak of "fighting in extended order and its combination with close formations." The former lay down, that on open ground the attack and defence, though introduced and covered by skirmishers, must be put through by the battalion, as a rule in column, and that it is only in an intricate country, where troops cannot move in close formation, that the latter must be looked upon merely as reserves, and the actual contest carried through by the skirmishers. The new regulations, on the other hand, while they admit that a battalion may possibly have to act in close formation, point out that in most cases those engaged in first line must be broken up into smaller fractions, and that the use of company columns must be the rule when the object of the engagement is to be obtained by the *fire* of the infantry. Proceeding to consider the question more in detail, they insist in the case of an attack in front,

1. On the necessity of previously subduing the enemy's fire by pushing the skirmishers up within close and effective range;

2. On the use of sufficient force in the attack; and

3. On taking *instant* advantage of any opening which the enemy may give; for which it is essential that the officers who are actually leading the troops engaged should act on their own responsibility in judging when to charge.

In the defence, the main points are to secure cover, either natural or artificial for the men, while obliging the enemy to pass over an exposed space under effective fire; and to confine the defence to one line only; the temporary occupation of advanced points being condemned, because heavy loss is sure to be incurred in evacuating them.* The pursuit of the enemy, when his attack has been repulsed, may be conducted by fire alone, and should be, unless it is possible to gain a fresh line in advance.

The increased effect of modern fire renders the front of steady troops practically unassailable, and enforces greater attention to the flanks both in attack and defence. Hence the necessity for considerable depth of formation, in order to provide for re-inforcing and prolonging a flank in line, or in echelon to front or rear.

The above remarks apply to the case of ordinary, tolerably open ground. In a close country the action will be almost entirely carried through by skirmishers and the importance of guarding by every possible means against the danger of the men getting out of hand is dwelt upon. In this view it is essential that no intermixing of battalions, companies, &c., which can in any way be avoided shall be allowed to occur.

The company column forms the subject of the next section (114 new, 122 old regulations) and here the difference between the two editions comes out strongly, not only in that the use of company columns is far more frankly accepted in the new one, but even more in the manner in

* It might be added that the notion of "temporary occupation" is too closely connected with that of giving way to be a wholesome one for soldiers.

which it is sought to provide against their acknowledged dangers. The edition of 1847 explains that company columns are useful in close broken country, but are unsuitable for open ground, and little capable of repulsing cavalry; and much stress is laid upon the danger of the companies getting out of hand, and the battalion commander's control being lost. In order to guard against abuse in this direction, definite limits are laid down, within which their employment is permitted, *e.g.*, that the companies are to be brought into action gradually, one at least being always in reserve, that the interval between companies shall not exceed 80 to 100 paces, &c. The present edition starts by saying that battalion columns are too deep to be used within range of artillery, and that accordingly the general employment of company columns has become matter of simple necessity. The risk of their getting out of the control of the battalion commander does not appear to be thought less of, but is guarded against in a different way. Officers are given to understand that it is their duty to rejoin their respective commands as soon as they have accomplished any service on which they may have been detached. At the same time it is distinctly expressed that the advantages offered by the skilful handling of companies by their own officers acting with a certain independence are to be turned to the fullest account.

Among the advantages attaching to company columns it is pointed out that they can obtain cover more easily than united battalions, that the men are more easily rallied in them, and that they provide very conveniently for a gradual development of force. In this latter respect the "Vortreffen," or advanced line, demands especial notice. A battalion in this formation would have in front a line of skirmishers, with supports 150 paces off,* both furnished by the third rank of the two flank companies; 100 paces behind the supports, the rest of the two companies would follow, with an interval between them equal to the front of two companies in line; the two centre companies would follow as a half battalion at 150 paces distance, and usually in rear of the centre of the interval. This formation is recommended as affording considerable depth and facilities for adapting itself to any line of action that may be advisable.

The last section of the chapter consists of "general remarks" which have been greatly amplified in the new edition. In their old shape they laid stress mainly on the importance of close and constant connection and mutual support between the battalion and its skirmishers. More definite principles are laid down now. For instance, a battalion when near the enemy must always be covered by skirmishers, so as to be perfectly secure against the danger of receiving infantry fire unexpectedly; every point won must be secured, the retreating enemy being pursued in the first instance by fire, then by skirmishers properly supported; the troops should never be more broken up than is essential at the moment, and detached bodies or skirmishers always tend to rejoin; the advance to be deliberate, the retreat calm and measured. Lastly, few forms, but perfect training in them; unflagging attention

* The distances are only for the drill ground.

to commanding officers, and thorough tactical cohesion are insisted upon as the essential points.

Chapters XIX and XX of Part V are devoted to the brigade and to developing with reference to the larger body the principles of action contained in the previous chapters on the battalion. The following are some of the points in which the new regulations differ from the old. Section 122. The distance between the first and second line is to be fixed by the brigadier according to circumstances. Section 123 allows all the battalions of the brigade to be deployed in a general advance; the old regulations prescribed the double column for the second line. Section 125. In case an attack has failed, the skirmishers are directed to hold their ground till recalled, or at least as long as the enemy will let them. Section 127 recognises the convenience of the echelon for advancing or refusing a flank, and for effecting a slight change of front in brigade.

The concluding section, headed "General Remarks," is much fuller and more elaborately worked out than the old one, and its instructions are based on somewhat different principles. While the old regulations admitted—apparently not without regret—that it was impossible to prescribe precise forms which should meet all cases, and that a certain freedom of action and individual responsibility must be allowed to Commanding Officers, even on the drill ground; the new edition not only accepts the fact heartily, but recognizes in it the means of arousing the intelligent interest of Officers, and imbuing them so thoroughly with the spirit of the regulations as to ensure its being always carried out in the best way that the circumstances of the case will allow. Certain evolutions are laid down, but only as examples, and Commanding Officers are required to practise modifications of them suited to the nature of the ground, the co-operation of other arms, and the measures of an enemy supposed or represented.

The vexed question which has been so much debated by German tacticians, whether the two regiments of a brigade should be drawn up side by side or as two lines one in rear of the other ("flügelweise," or "treffenweise")—affords a good illustration of the practical character of these regulations. It is alluded to incidentally towards the end, the arrangement of the brigade throughout the preceding sections having been spoken of as in two lines, one regiment in each, or in three lines, one battalion of the regiment which forms the first being advanced, or one battalion of the other regiment, which forms the second line, being held in rear as reserve. It is pointed out that circumstances may make it desirable that the regiments should act side by side, as, for instance, where the action would turn on the possession of two more or less disconnected points of a general line, or where great depth of formation and special attention to the flanks were in place. The essential point is shown to be, that the regiments should, as far as possible, be kept distinct and unbroken, and intermixture of battalions, companies, &c., be avoided.

The observations contained in pages 198–201 are so characteristic of the spirit of the book that I think I cannot close this slight survey better than by a free rendering of their contents:—

"Officers commanding regiments and battalions must be accustomed "to at once adopt measures suited to the circumstances, keeping ever "in view the general purpose of the engagement and the normal order "of battle. They must be prepared to direct the fire and the attack of "their troops to the best effect, and to modify their action, if necessary, "at any moment. For instance, if the enemy's attack were to strike "on one part only of the line, the battalions which are not threatened, "or some of them, should act against his flank. A battalion advancing "must alter the direction of its attack if it finds that it will not bring "it against a suitable object; if it were to strike on two contiguous "bodies of the enemy, it might be necessary to break into two half-"battalions, or, while attacking one body, to bring forward one of its "rear companies on the flank of those in front. Should the enemy "threaten the flank of the first line, he must be taken in flank himself "by the battalion of the second line which happens to be most con-"veniently placed," &c. &c.

"Particular attention is to be given to keeping a suitable distance "between the lines. Occasions may arise when the second line should "be pretty close up; but, as a general rule, its part in action will be that "of a reserve; more especially when, as will usually be the case, "there is an advanced line, 'Vortreffen.' It is only when the imme-"diate co-operation of both lines is wanted that the second should be "near the first.

"A change of lines"—the practice of relieving one line by the other—"in presence of the enemy is to be avoided; and the employment of "the second line deferred as long as possible. The fighting power of "the first line should be worked out. It is secured against disaster "and the enemy's counterstrokes by the second line being kept in "hand.

"When the second line is brought forward, it will as a rule be on "one or other flank of the first, so as to avoid intermixing the regi-"ments. This may often be judiciously effected by advancing it right "and left of the battalion of the first line on that flank which is "hardest pressed; the latter being then withdrawn and rallied in rear "of the other two battalions of its own regiment.

"Brigades and regiments must further be practised in assuming the "formations best calculated to diminish the effect of the enemy's artil-"lery. In view of this, it may be observed generally that formations "of minimum depth are in place under shell, and columns of small "front under case and shrapnel fire.

"The preference for attack which is characteristic of our infantry "is to be kept up and encouraged; and the formations which are suit-"able for the purpose should be much practised. At the same time, "bodies of troops, large or small, must be rendered perfectly familiar "with the evolutions which are necessary to bring out the full effect of "their fire.

"Whenever a tolerably clear range presents itself and a prompt "decision of the fight is not called for, it should be the aim of infantry "to make the most of the great superiority which is enjoyed by steady "troops in position who fire with coolness. The men must, therefore,

"be trained to resort instantly, at any moment and in any phase of the "action, to the use of their rifles and to develop the effect of their fire "to the utmost, though perhaps only for a short time and in order to "resume the attack with fresh vigour and larger chances of success "against the shaken ranks of the enemy.

"In fact, the conduct of infantry in action may be said to turn essen-"tially on the judicious application of their fire, concentrated as to "time and place, and on taking instant advantage of the disorder and "demoralization which it will produce in the enemy's ranks."

The concluding sentence contains the pith and marrow of the book. The two main ideas which run through it and underlie its provisions for the attack and for the defence alike, are:—1. The fullest effective use of fire; and, 2. The instant use of the opportunities which it produces.

The theory which used to prevail in continental armies and on which the old Prussian regulations were founded, trusted for success principally to the employment of troops in close order. The effect of fire could not, it was considered, except on rare occasions, *decide* an infantry engagement; it could only introduce and pave the way for the attack of the column, disturb the enemy's formations, make his men unsteady, and render them more accessible to the terror of the charging masses by which the final stroke was to be delivered.

This theory has yielded to the stern logic of facts. It was seen to be obsolete in 1866, when the Austrians strove in vain, clambering over the bodies of their fallen comrades, to grapple with the enemy; but the lesson was not fully taken to heart till Spicheren and St. Privat had urged it home, and proved to demonstration the strength of the breech-loader in position.

Since then a change in tactics has been acknowledged to be inevitable; but the conditions of tactical success remain unchanged. It is as necessary now as formerly to force the enemy to fall back; only the compulsion must be exercised in a different way. The fire of the defence must be turned or overpowered before an assault can be pushed home. The conduct of an Infantry attack in the present day has become in principle the same as that of a regular siege. The converging fire of the assailant must be pushed up under cover—obtained in one way or another—and concentrated on some one point of the enemy's position till that of the defence collapses; then the breach must be instantly occupied and secured.*

It was foreseen years ago† that the change of tactics consequent on the improved Infantry fire-arm would be in this direction. Attention has been pretty generally called to the fact by the works which have been published since the war, and now that it has been registered, as it were, in the new Prussian Regulations it will probably be universally accepted.

* Cf. Sir G. Wolseley, "Soldier's Pocket Book," pp. 241–3, second edition; also v. Boguslawski, "Tactical Deductions from the War of 1870–71," translated by Col. Graham, cap. iv, pp. 75, *et seq*, and the Translator's preface.

† V. Moltke, "On the Influence that Arms of Precision have on Modern Tactics."

But even now when it is clear enough what is wanted, the path by which it is to be reached is by no means so plain. The only conditions on which it is possible for Infantry to attack a position are, that the men shall be moved forward in loose formation and by degrees, and yet shall be at every moment under the complete and absolute control of the Officers who lead them; and that the latter, *i.e.*, the Officers in the skirmishing line, shall act on their own discretion, and in concert with one another in making the final rush.

It would not be easy to over-estimate the difficulties of the task, and it is evident that the Prussians see them clearly enough. There is scarcely a page—I had almost said a sentence—of the "general "remarks" which does not indicate that they are fully realized and fairly grappled with. Let us see what the demands are, which they make on their Officers and men; and what kind of men and Officers they are on whom such demands are made.

The passages just quoted from the chapters on the brigade indicate what is expected from the higher Officers, and I would only draw attention further to the fact that their duty, according to Prussian instructions, appears to be confined to the general direction of the action. They are not charged, nor are they expected to mix themselves up, with the details of the actual contest, but must hold themselves clear of its inevitable confusion in order that they may the more effectively influence its progress.

The management of the details devolves upon the Officers of subordinate rank, from the Captains of Companies downwards. Theirs is the immediate conduct of the actual fighting, either in first line among the skirmishers, or with the supports, or "Vortreffen" in rear. As regards their duties we find laid down* "Officers and Non-Com-"missioned Officers" in a line of skirmishers "must use every exertion "to keep their men in hand, and more especially to direct their fire. "It is their business to specify the object to be fired at, the distance, "and the sight to be used, and to regulate the intensity of the fire. "They must see on the one hand that the men do not waste their am-"munition, and on the other must recognize the occasions which call for "an unsparing use of it."

"They have to keep their attention constantly fixed on the enemy, "and on the nature of the ground, and to judge how the line, or part of "it, may be pushed forward, whether and how the enemy's flank may "be gained, or an attack made on it. They are expected to seize at "once, and turn to account any opening he may give, and to consider "whether it may not be possible to obtain decisive success by concen-"trating and intensifying the fire of the line on some one point of the "enemy's position, and then breaking, and either dispersing or rolling "up, his line by a quick vigorous charge."

The Officers in second line have the scarcely less difficult duty of keeping the supports and the main body of their companies out of fire, but within reach of the skirmishers, and of feeding the action at the right spot, and in the most effective way. The regulations point out† that

* Part iv, cap. 17, sect. 108, page 156.
† Part iv, cap. 18, sect. 113, page 166.

"the attention of Officers of all ranks must be particularly directed to "keeping up the connection of the different parts of the line with each "other and with the supports and reserves, and to ensuring the orderly "conduct of the action. In this view it is essential that men of different "corps (companies, battalions, &c.), should not be allowed to get mixed "together. It is to be considered a rule that a body of troops reinforcing "another shall be brought into action on one or other flank; the only "admissible exception is where it would be impossible or palpably mis-"chievous."

So much for the Officers. What is required of the men may be gathered from the closing sentences of section 43 (Chapter IX, page 75). "The company must be able to execute the simple formations and "movements which are necessary in action under all circumstances, by "day or night, in inverted order and without telling off. It must be "prepared to form in any direction, to the right, the left, or both right "and left, on the leading file, towards either flank or to the rear, in close "or in extended order, with perfect certainty and speed, and to change "as quickly to any other formation which the progress of the action "may render necessary. This perfection is not to be attained by laying "down precise forms which tax the soldier's memory. *On the contrary, "the company must be trained to such a point that it shall be always "altogether in the hand of its leader, and the men's attention must be "riveted so entirely and uninterruptedly on his orders that they may be "carried out even without previous practice.*"

These are enormous demands to make on Officers and men. They ask from the latter at least all that was formerly required, and in addition, a degree of independent intelligence and mental activity which it has not been usual to calculate upon or even to wish for. The officers of all grades are expected to display not merely such knowledge of their varied duties as may be learnt, but judgment, coolness, untiring energy and vigilance, prompt resolve, and equal readiness to assume responsibility or to lay it down. Such would appear to be the standard to which the Prussians invite their soldiers to attain, and the conditions on which alone they believe that an infantry engagement can be carried through with success. If they are right, if all future fighting will have to be done in extended order, and the chance of victory turn on the greater or less degree in which the officers in first and second line can maintain effective control over their men, and seize the right moment for closing with the enemy whenever it presents itself, we can have no difficulty in admitting that a lower standard will not do, and that it would be absurd to make smaller demands on either officers or men, or to trust them less.

We cannot enter now on the question whether theirs is the best or the only possible solution of the tactical problem, not for their service only, but for others; though these are questions of the first magnitude and interest, and the answers to them cannot be long deferred. But before they can be satisfactorily answered, the conditions must be clearly recognised, on which alone the Prussian solution of the problem is possible. It is idle to make demands on men to which they cannot respond, and I think we may dwell for a few minutes on the singular

advantages which the Prussians enjoy, and which justify them in setting up an unusually high standard of training for their army.

I pass over facts which have been amply illustrated on previous occasions in this room,* and confine my remarks to the one point of training. In the first place. there is the high intellectual average of the private soldier, and the discipline of sobriety and obedience to which he has been accustomed in his family and at his school. Baron Stoffel observes† "Pourquoi la discipline est-elle si forte et si sûre dans l'armée "Prussienne? Par la simple raison que les jeunes gens entrent au service "tout disciplinés, c'est-à-dire, façonnés depuis leur enfance à l'obéissance "en général, au respect de l'autorité et à la fidélité au devoir. Il en "résulte que les officiers ou les chefs n'ont presque rien à faire pour "maintenir la discipline et ainsi s'explique par quelle raison on ne "compte qu'un très petit nombre de punitions dans l'armée Prussienne." The recruit joins his regiment ready and willing to learn. What does he find there? By whom is he taken in hand? Who and what are his teachers? They are the officers of his company. I say the Officers, because the first merely formal instruction of the recruit, which is given by the non-commissioned officers, is given under the strict and constant superintendence of an officer; and the instruction, which is not merely formal, which is intended to fit the soldier for the field, is given by the officers of the company themselves.

Thus the young soldier who comes into the service prepared to learn comes at once under the eye and training of men whose intellectual superiority, knowledge of their work, and sense of duty‡, he cannot fail to perceive, and is more or less qualified to appreciate. The brigade, the division, and the corps, are somewhat vague and shadowy conceptions to the recruit; the utmost that they convey to his mind being the satisfactory idea that he is a small unit in an enormous organization of indefinite dimensions and irresistible strength. Nor does he feel that he belongs altogether to a regiment, or even to a battalion, until he has been dismissed drill. But in his company he finds at once, only under a different form, the authorities with whose watchful interest he is not unfamiliar, the old village companions and something even of the loving, and perhaps fussy, guidance of his home.§ He learns to look upon the Captain and his Lieutenants as men who have mastered the whole science of fighting, and who devote themselves to teaching him what they know. We have no occasion to raise a question whether the Officers of the Prussian Army give themselves more wholly to their work than those of other services; it is enough for our purpose to recognise that they do so to an extent which leaves little, if anything, to be desired; and it is also true that their time and thoughts are not taken up by a multiplicity of accounts and returns.|| The whole

* See Journal, Vol. xv, No. 63.

† Introduction, p. xxi.

‡ Compare Stoffel, "Rapports Militaires," &c., pp. 101, 103–4.

§ Compare Boguslawski, "Tactical Deductions," &c., p. 17.

|| The men are paid and their accounts kept by the Battalion Paymaster; the Company Officers take care that their men get what they are entitled to in pay, clothing, food, &c.

weight of the training through which the troops are put year by year is thrown into the single endeavour to fit them for actual service, and is conducted by the men who will lead them against the enemy when the day of battle comes.

It will be admitted that these are exceptionally favourable conditions for bringing out the necessary qualities, for getting soldiers accustomed to surrender their will to their leaders without sacrificing their intelligence or zeal; and officers trained to lead, not merely to command, their men. But something more is wanted. After all has been done that can be done to place the men thoroughly in their Officers' hands, the standard of required perfection cannot be approached unless the Officers themselves can be trusted to rise to the full level of their responsibilities. We have seen how wide is the range and how difficult the nature of their duties in action; how much is asked from them of cool judgment and of ready daring, of self-abnegation and submission to authority combined with a manly craving for responsibility and an ardent desire for distinction. The task is severe and the training careful in proportion. Its whole aim and essence is to make the Officers complete masters of their work; that work being primarily, if not exclusively, the conduct of their men on the field of battle. Nothing, for instance, is more striking in the management of the Prussian war-schools, through which the Ensigns have to pass before they are commissioned as officers, than the thorough character of the teaching and the extent to which the student is led to think conclusions out for himself. The subjects of study are purely military and the ground gone over in each is limited; but the work within the limit has to be done *bonâ fide* by the student and requires a distinct exertion of the mind. There is absolutely no place for cramming.

Again, the system which makes the Officers of a company answerable for the training of their men provides the best possible training for themselves. It renders them of necessity familiar not only with the individual character of their men, but with the minutest details of their work, and gives them self-reliance and the habit of command.

Lastly, the annual manœuvres, and, in preparation for them, the exercises in company, battalion, regiment and brigade afford opportunities for practising officers in much of the work which would devolve upon them in war, giving them real freedom of action and accustoming them to real responsibility. We find in the official "Regulations for the Manœuvres, &c." p. 8, "the exercises will be useful in proportion as "they give the subordinate officers opportunity for independent action."

If then great demands are made upon the troops in Prussia, they are at least made deliberately and with reasonable prospect of their being responded to. No effort is spared to qualify officers and men for their work by judicious, thorough, and severe training. Opinions will no doubt differ, not so much as to the excellence of their system in itself (though it has not yet been subjected to an exhaustive test), but on the question whether it is suited for other armies. But this much is certain, and it is a point on which it is impossible to insist too strongly. Prussian tactics do not stand alone, they are only one aspect of a very

extensive and carefully elaborated organization and are founded on, or rather have grown out of, their system of training. That system exacts more from the troops, and trusts them more freely and fully than is the case elsewhere; it is minute, thorough, and eminently practical, being directed almost exclusively to prepare the troops for actual service, and to link all ranks of the army together by bonds of mutual confidence and respect. I believe it to be essential to the proper working of their tactical principles, and that any attempt to imitate the latter without having first laid the foundation in a training similar to theirs, will result in disappointment, if not in something worse.

I had nearly finished sketching out what I proposed to say this evening, when my attention was recalled by a friend to an excellent little work which dates as far back as 1837, Gawler's "Essentials "of Good Skirmishing." It was revised by the author, Colonel Gawler, formerly of the 52nd Light Infantry, in 1852; and it is curious to observe how much there is in common between the views which it enforces, and those of the regulations we have been considering. Allowing for the difference of armament and the careful way in which the Prussians have worked their system out, we recognize in the most approved tactics of to-day, much of what seems to have been the practice in the old Light Division towards the close of the Peninsular war, when those magnificent regiments had gone through the rough and ready training of eight campaigns. Let us have the closest imitation of such training that we can get in time of peace, let us apply it always and to all our infantry, let men and officers know that it is their real work, that their business is to prepare for actual service, and not for mere parade, and I venture to think that the English Infantry will run no risk of falling into the most dangerous of all delusions, and fancying that real excellence is to be gained by merely copying its neighbours.

The CHAIRMAN: Major Jones has given us so clear, succinct, and at the same time so comprehensive a sketch of the contents of the Prussian Drill-Book, that I think we cannot but feel extremely grateful to him for it. There are many gentlemen present who have made Germany and the tactics of the Prussians their study, so that I hope the lecture will form the basis of observations which they may be pleased to give us. Sir William Codrington, more especially, who lately gave us an interesting lecture on the Prussian manœuvres of 1869, will, I trust, lay before us some of those ideas which Major Jones's lecture will have suggested to him, and which I am sure will give great satisfaction to all present, as illustrating that lecture, and also as throwing fresh light on the Prussian manœuvres so ably explained to us the other day.

General Sir WILLIAM CODRINGTON: It is a very kind invitation, but we come here unprepared, the Lecturer comes fully prepared in writing. There is one thing we must all remember, namely, that every nation has its own individuality of fighting, dependent upon national character, dependent upon conscription or non-conscription, and upon other circumstances; so that we cannot quite put a system for England in a parallel line with that of any other nation. France, Austria, Russia. Prussia have conscription; we entirely volunteers. There is no doubt that the difference in the quality of the recruit is great when tested by this fact. In the Prussian army, and I presume in other armies, you get a mixture of different classes, and an infusion of higher education, that you do not get in the ranks in England to the same extent. Our object should be to utilize entirely those qualities that we find in private soldiers, independent of the consideration whether another army is superior by education or by conscription. Therefore, we cannot apply

exactly the same rules that may be beneficial for other nations. With regard to the general question of the tactics of company-columns and columns generally, I understand that the system is changed since the time that I happened to witness it in operation in the peace manœuvres of 1869, in Prussia.

Major JONES: So far changed that skirmishers advance to attack a post in a different way.

Sir W. CODRINGTON: But I apprehend very much on the same principle?

Major JONES: The company column I do not think is changed.

Sir W. CODRINGTON: If so, the same principles are laid down in the drill book now, that were carried out before the war of 1870; because after all the war of 1870 in France is the great test. Certainly, before 1870, I saw—as I mentioned in a lecture here—in four different corps of 25,000 to 28,000 men each, movements of columns under artillery fire that any English Officer would think dangerous to a high degree in war. I was not the only one who saw this, for there were twenty-one English Officers present. It was the subject of conversation and of discussion with the German Officers as well as the English Officers. I did not quite understand from the Lecturer whether there has been a change in distance of the company column and the battalion column. I constantly saw them within twenty-five paces of skirmishers exposed in peace apparently to what in war would be a severe artillery fire, that is to say, positions where artillery would be, and I do not know whether any change has actually taken place in the drill, of which that was the result before the war. Perhaps the Lecturer will be able to tell us what is now the rule; for the means of getting men up to a defensive position, or to troops defending themselves, without the extreme loss consequent upon the use of breech-loaders, is a subject of great interest to English, as well as to foreign troops. There is this also to be remembered, that however good the advance of skirmishers may be, we know that the enemy has skirmishers as well as the party attacking. It does not follow, if you are to attack that further side of the table where there is a defensive position, and your skirmishers advance from this side, that you can get your men close up to that position by commencing in open order, and closing near the enemy; for we may suppose he will have skirmishers equal to those of the attack, and, therefore, it does not follow that you have the movement in your own hands. To have the benefit of open order first, and concentration for main attack, you must get past your enemy's skirmishers before touching his main position. I do not know how the Prussian drill-book now gets over that possible difficulty. If there has been a change, which I hope the Lecturer will be able to tell us, since the war of 1870, it has arisen from the experience of 1870, in which the movement in column under fire, subjected the Prussian troops occasionally to frightful loss. In any question of English lines—in any question of the Prussian system of fighting, skirmishers at the last must form some sort of line; that is to say, they must put themselves in the position for each man to have most individual power, whether that is by fire, or whether by the bayonet. I hope we shall hear with regard to company-columns and battalion-columns, and even brigade-columns forming a mass of six and seven battalions, which I saw during peace in positions liable to artillery fire, whether the new drill has done away with that practice, and with the probability of such losses as took place at St. Privat, Spicheren, and other places. These are the remarks which I think it necessary to offer. If the Lecturer could tell us that there is a total change of system, namely, of not putting columns under fire, and could tell us how the battalions and brigades, I mean the substantial masses of troops, are to advance to a position that is defended by lines and by skirmishers in front of those lines, it would be advantageous to us all. I may perhaps add another question. Would the Lecturer cite, by the experience of the war of 1866 (a successful war on the part of the Prussians), or that of the war of 1870 (also a successful war), a single instance in which skirmishers, as skirmishers, have taken a position solidly defended?

Colonel E. NEWDIGATE: I had the pleasure of being at the same manœuvres as Sir William Codrington, and having taken a great deal of interest in this present drill, I would only remark that the distance between the line of skirmishers of a Prussian battalion and the main body of the battalion is 400 paces, in the regulations for exercise. It would be increased under fire. It is divided in this way. First of all, there are skirmishers sent from the flanks of each battalion. Then comes a small

independent support to fill up casualties. Then the remainder of the flank companies, and then the two centre companies, which are 400 paces in rear of the line of skirmishers. That is a great deal further than the distance to which Sir William has referred; but, of course, at all manœuvres mistakes are made. As regards that formation for manœuvre, it struck me at the time as being the best possible formation adapted for manœuvre. If line was required to be formed, as it might be, it would be done by bringing up the rest of the battalion to the skirmishers, instead of clearing away the skirmishers. It takes time and loss to bring formed lines up to where they are required, or to pass from them to any other formation. The small columns were most convenient for manœuvre. With regard to the attack, last winter I was in Germany, and observed the companies at company drill, all under the command of their captains. They practised throwing out men in any direction, any of the men of the company, as skirmishers. Then, for their attack, they always brought up the main part of the company into the centre of the skirmishers, and went through to attack in that way. Their attack was made by the closed body of the company, either formed in line, or, perhaps, in column, which came up to the centre of their own skirmishers, and with them made a rush upon the position. This is what they were practising. The captains were practising this sort of work with their companies almost more than anything else: throwing out any men as skirmishers, re-inforcing them if necessary, but generally bringing up the company in some shape or other in the centre, and going with a rush to attack a position. It seemed to be the chief object of instruction. (Colonel Chesney: You mean in advancing.) In advancing to attack a position. This was only company drill. If I should not be taking up time, as Major Jones has referred to my translation of the drill book, I would mention a mistake that occurs in the passage, "if the intervals *between the files* are too great, another section is sent up." Now, one of the great principles in the Prussian drill is, never to send one lot of skirmishers up into another, but always to send them on the flank of another, either to prolong it in some way, or to fill up the gaps between the skirmishers of one company and the skirmishers of another. Because the companies act independently, one company goes up, another company goes up, and if there happens to be a great gap, they send from the rear company's battalion another independent lot into the centre. I ought therefore to have said, "If the *gaps* are too great, another section is sent up."

Lieut.-Colonel Chesney, R.E.: I wish to ask one question. Do you know if they have given up the practice of bringing up supports in the defence into the line of skirmishers to fire volleys? because that is what I hear from Prussian officers is to be one of the things abolished when they are in advance at all. Do you know whether they do it practically in their drill?

Colonel Newdigate: I think it is abandoned, for this reason, that they have a very strong body of skirmishers in the first line of defence. In that case the fire of the line of skirmishers is as great as could possibly be used. The fire of a close line is a great deal more than can be used. I mean that the smoke is too great. I saw it at the last Brighton Review. The skirmishers, who were six paces apart, were firing so quickly that they could not see what they were firing at. Therefore, the fire of a close line is a great deal too great. It was proved so with the French, they fired away all their ammunition. It is especially in the defence—as it is understood in the new regulations, that this deep formation is of great value, because the supports and reserve being so far back, can wheel to the right or left, and at once form a line to resist a flank attack.

In reply to a question by Sir William Codrington, Colonel Newdigate further explained that from the line of skirmishers to the main body of the battalion in company-columns was 400 paces; that there were two company columns in the centre, and one company column on each flank, (Colonel Newdigate here drew a sketch on the black board) that the outer skirmishers formed the first line of skirmishers; then a small support 150 paces in rear of it by way of filling up casualties in their own subdivision, and then the remainder of the company in two sections, *Züge*. That was altogether 400 paces from the line of skirmishers to the main body of the battalion, which was far more than what they saw when they were at the manœuvres.

Colonel CHESNEY: I think I can give some small contribution to the points in controversy—if that is not too strong a word to use—as to what Sir William Codrington saw in 1869, but I can speak only from hearsay. I went over after the war of 1870, but I was very unfortunate in one respect, as I hardly ever saw any drill in the Prussian Army, but I heard this constantly said, that, before the war, the cry was, "always keep your supports up close to the skirmishers." The idea was, that the moral effect of keeping the supports near the skirmishers was so great, that it far outweighed any disadvantage that they might suffer. But the practical effect of the war was to show that you must not keep the supports near the skirmishers, unless you had cover for them behind. In the same way at the latter part of the war, the distance was very greatly increased. It was found that the troops, at shorter distances between them, could not advance against the French armed with the chassepôt, without suffering enormous loss.

Colonel NEWDIGATE: That partly accounts for the small "supports," because, when Sir William Codrington and myself were there, that little support did not exist.

Sir W. CODRINGTON: Supposing the skirmishers were taken at one-third, which I think was the principle of the Prussian attack at that time; of course, there would be two-thirds of the company in rear as a support. (Colonel NEWDIGATE: Exactly). Then if there were 250 men in a company, and one-third were told off as skirmishers, that would leave about 160 men in a company column of sections; that is to say, a small column of sections. But though a small column of sections, it is a very large mark for artillery. That is what I observed in the Prussian reviews in 1869. And not only was it a mark for artillery, but it was from twenty-five to thirty yards only in rear of the skirmishers; and the battalion the same distance, as it were, from the reserve of the company column. That is the fault, I imagine, that has now been changed by the adoption of these greater distances, so as to avoid artillery fire.

The CHAIRMAN: There is an officer present, Captain H. Brackenbury, R.A., who saw much of the war in his own department, and, no doubt, witnessed the operations of both the armies engaged. I would ask him, if he had the opportunity of observing the Prussian mode of attacks, to give us the advantage of hearing his observations upon it.

Captain BRACKENBURY: It seems almost presumptuous in an artillery officer to venture to say anything on this question of infantry drill. But I think the great point to look at, is the spirit of these Prussian tactics, and not so much the drill formation of any given small body of troops, because the spirit of the whole Prussian regulations seems to be, that any given formation is liable to be immediately varied at the discretion of the Commanding Officer to suit the circumstances in which he finds himself at the moment. I take it, for instance, that this formation of the battalion in a Vortreffen, and Hauptreffen, is as we see it on the board, or as we find it in the drill-book only, as it would be before a single man has been lost. Practically, we find that about one-twelfth of a battalion covers the whole front as skirmishers. Half a subdivision from each of the flank companies with an interval, which, by the Prussian drill, is not to be exceeded, of six paces between the files will cover the whole front; that is one-twelfth of the battalion. Only another one-twelfth of the battalion is there in support. Then, we have one-third of the battalion as the reserves. Then, finally, we have one-half of the battalion remaining in a second reserve. The battalion goes into action like that: its half-battalion remains behind, half sub-divisions going to the front as skirmishers, and other half sub-divisions as supports. What happens when you get into action. The skirmishers begin; then, the skirmishers are strengthened by the supports; the reserves come up to fill the place of the supports; and, then, the main body becomes very rapidly a small column. With regard to what Sir William Codrington has said as to getting through a line of skirmishers, it is distinctly stated in the Prussian drill-book that a position properly held is unassailable in front; and it is laid down that the men are to be taught that a position is unassailable by a front attack. (Sir W. CODRINGTON: Since the war?) The new drill-book has been produced since the war; but I think I am correct in saying it was written before the war, that a position is unassailable in front. As Colonel Newdigate said, the skirmishers are to be

strengthened not in front, by sending supports to fill up the line, but by sending those supports towards the flank, I think if you look at the whole spirit of these new Prussian formations, and look at this formation as we see it in on the board, it comes to this: We have a centre; that centre is formed by reserves. The enemy's artillery or the enemy's troops form, we may say, a great circumference with a very long radius, longer than any artillery fire, from that centre. The skirmishers form a chord of the arc of that circumference. Going a step further than the battalion, Moltke's proposal for the formation of an army corps for the defence of a position, is nothing more than that Vortreffen, and Hauptreffen on an extended scale. It is a brigade occupying a front, with battalions in this formation. Then another brigade as a sort of main-body in rear of that; and then a whole division as a reserve. The division in the reserve is the great centre; and so it tells us what is the whole essence and spirit of their tactics. In acting on the offensive, use a small body in the front, and keep your reserves well back. In defence always send the supports to your flank, whichever flank is threatened, because there is no danger to your front, it is your flank which is the dangerous part. Here it seems to me to be exactly the same thing. The whole spirit of this formation is, use a very small body in front, because a line even held by skirmishers in comparatively open order, is unassailable, and keep your supports and reserves for your flanks. Next, with regard to what Sir William Codrington said about the advance of columns under fire. I have good reason to believe that on the 27th September and on the 30th November the working was particularly what the Duke of Wurtemberg tells us was ordered to be done after the 18th August; namely the advance of the supports and reserves to strengthen the shooting line, themselves in extended order, always working in extended order. Now, I believe the object of Major Jones's lecture to-night is not so much to teach us what the Prussians are doing, as to lead us to think a little for ourselves. We have in our own infantry drill the working of skirmishers. I venture to think that the essence of the Prussian skirmishing system, is skirmishing by section; placing in the hand of an intelligent non-commissioned officer a small body of men, so small a body that they can easily be handled and controlled by one man, and can easily find shelter, that man really controlling them. We have lately introduced the system of skirmishing by sections into the infantry service. I believe it will be absolutely necessary for us to train our non-commissioned officers in the duty of skirmishing in this spirit, and not merely in the letter. In our system of attack, let us look at what we do. If we have a battalion in line, we throw out, perhaps, a company of skirmishers, and another company to support; and then the remainder of the battalion moves as a sort of reserve in line. I believe in the Prussian drill an advance in line against the enemy is a thing which is not contemplated, practically not contemplated. Is it not so?

Major Jones: I do not think they positively exclude it; they do not positively exclude anything.

Sir W Codrington: I saw it in 1869.

Captain Brackenbury: I think I can unhesitatingly say that they never advanced in line against the enemy.

Colonel Chesney: They did not in 1870.

Captain Brackenbury: They never advanced in line against the enemy, but the French did. I heard of one or two examples of the French advance against the enemy; and as this question is so much under discussion at present, I thought it might be desirable to be able to quote an instance of an advance in line and the result. I wrote, therefore, to Paris, and I got only this evening, from a senior Staff Officer of one corps during the war, an account of a French advance in line. It is so remarkable that I think it would be interesting to this meeting to read it if I may be allowed. This was at the battle of Rezonville. I will first state the circumstances. It is doubtless known to everybody here that the battle of Rezonville was fought on the 16th August. The second corps was on the extreme left of the French army; the sixth corps was on the right of the second. Comparatively early in the action, the second corps was demoralised by the Prussian fire, and driven back, and it had to abandon the position it held. This, which I will read, is written to me by the first *aide-de-camp* of the Marshal who commanded the

6th corps in campaign, the corps that suffered most in the battles of Rezonville and St. Privat, on the 16th and 18th August:—

(TRANSLATION.)

"On the 16th of August, about one o'clock, at the battle of Rezonville, the Commander of the 6th corps, returning from his right, which occupied St. Marcel, towards his left which rested on the Verdun road, some hundreds of metres in front of Rezonville, saw from the other side of the road a movement of retreat on the part of the 2nd corps, and a movement of attack by the Prussian infantry on the hamlet of Flavigny.

"He immediately directed the 94th regiment of the line to move on Flavigny; then, as much to sustain the morale of his men in presence of the retreat of the neighbouring troops as to aid in arresting the movement of the Prussians on Flavigny, he led forward two battalions of the 93rd, deployed, preceded by skirmishers at three or four hundred metres in front.

"Masked until this moment by a dip in the ground, these two battalions were scarcely out of cover, when they became the mark for such an artillery fire that they could with difficulty pass over a few hundred metres, and wavered (*fléchirent*) under the fire which was crushing them, and in a few minutes many hundreds of men were placed *hors de combat*. This fire proceeded from the great battery established by the enemy in rear, and to the south of Vionville, that is to say at more than 3,000 metres from us, which battery, suspending its fire on Flavigny, had concentrated it on the battalions at the moment their movement in advance was made out.

"This battery was armed with 24 pieces according to some, with 36 according to others, a portion of the guns being covered by a breastwork. At this moment the Prussian infantry were about 2,000 metres from us, between Vionville and Flavigny, and their fire caused us no harm.

"The battalions of the 93rd, which took part in this movement, contained a great number of young soldiers, inasmuch as the evening before the battle, this regiment had received at Metz a contingent of 900 men who had never touched a Chassepôt. Nevertheless, these battalions did not recoil under the fire, though they wavered (*fléchirent sur eux-mêmes*). I doubt if older troops could have prolonged their movement in advance much longer than our young soldiers did, who were led by the Commander of our *corps d'armée* himself."

That is, I think, a very remarkable example of the impossibility of advancing in line under the fire of the present arms. Here are guns at a distance of upwards of 3,000 yards. (Colonel CHESNEY: Or supposing even it is exaggerated). We know the distance by the map, and, roughly, it is not very much out. From where the Prussian guns were beyond Flavigny, it is from 2,500 to 3,000 yards. But, supposing the movement commenced at 2,000 yards, the fact still remains, that under artillery fire alone, without infantry fire two battalions in line lost several hundred men before they had gone some hundreds of paces. In the face of that example, in the face of one or two others which we know, we must seek for some means of having the spirit of this Prussian system of drill, which is the abandonment of anything like a rigid, close formation when once within thoroughly good, active range of the enemy's fire. 2,000 paces is what the Duke of Wurtemberg has stated as being the limit within which troops were not to be moved in close formation. How, then, are we to seek, and where are we to find a new system which will allow us to move in loose order, and at the same time rally at the decisive moment. I believe Major Jones himself is thoroughly of opinion that there is no necessity for adhering slavishly to the Prussian system. (Major JONES: Quite the reverse). The secret is to be found, not in adopting a third rank, not in the adoption of the Prussian company column, but in the adoption of the spirit of the Prussian system; in the first place, in the accurate and careful training of the officers and men, to work in open order and to rally; and, in the next place, in the abandonment of a rigid formation which it is impossible to adhere to under fire—in fact, such a modification of the Prussian system as is suited to our own existing formations. A great deal, I believe, will be found to hinge on a thorough system of section

skirmishing. It is not necessary to have three ranks, or to adopt the Prussian drill formations, in order to obtain that.

Major JONES: I think there is very little for me to say in reply to the remarks that gentlemen have been good enough to make. My answers have been to a great extent anticipated by Colonel Newdigate, and Colonel Chesney, and by Captain Brackenbury. I may mention, in confirmation of what Sir William Codrington said, that I have understood that in the earlier actions of the late war, *e.g.*, at Weissenburg, the same fault occurred which he noticed in the manœuvres of 1869, namely, that bodies in close formation did get under the enemy's fire, and suffered severely. One question that I understood Sir William to ask was, "how columns are to approach lines." I do not see that they can approach them.

Sir W. CODRINGTON: I did not ask how columns were to approach lines, but whether their skirmishers in open order had ever taken a position as skirmishers, which was well-defended.

Major JONES: It might perhaps be said that if skirmishers did take a position, it could not have been well-defended. But one side or other must be beaten, and I think we might instance as positions taken by skirmishers in the late war, the actions before Orleans, Le Bouget, Le Mans.* (Colonel CHESNEY: Take the battle of Wörth, the fighting was done by skirmishers). The difference of force was so great that I did not like to quote it. But I think the real question is, not so much whether we can quote distinct instances where skirmishers have taken a position or been defeated; but suppose we have a position to take, how are we to set about it? If we can do it in our old way, with the steady English line, well and good, let us do it. But if we cannot, and our solid English lines melt into thin air, and we lose all our men, as the French battalions Captain Brackenbury has mentioned lost theirs, I should be sorry to see the work attempted in that way. Then, the question remains, how are we to do it? That is the question to the importance of which I have been anxious to direct the attention of Officers who are far better judges than myself. I do not think we can venture to go into a war (at all events with any European nation) without having some notion how that question is to be answered, and I confess I do not think it is at all an easy question to answer.

There was one remark that fell, I think, from Colonel Chesney, which has reference to the Prussian practice in the matter of moving up their supports.

I think the introduction of fire in four ranks may probably have been intended to apply in the case of the supports being brought forward in the defence of a position. The point was whether supporting divisions were ever brought up into the line of skirmishers in close formation. The only instance which occurs to me was in the repulse of Garibaldi's night attack near Dijon, on the 25th November, 1870 (v. Blume, p. 104), where the Prussian outposts are reported to have fired volleys. As a rule I should suppose the supports would be extended before they moved up. But the discretion left to Officers is so large, that no doubt they would be kept in close formation whenever possible; in that case the fire from 4 men from four ranks would be got to bear upon any particular point if concentrated fire was required.† I do not think there is anything further to add. The discussion has, I think, brought out very much what it was desirable should be brought out; and if it has produced the effect of drawing the attention of Officers to the very great importance of the questions which devolve upon us all, professionally, and if we put our shoulders to the wheel to solve them, as I said before, I do not think we need go beyond our own English experience; and I am sure that if there is any infantry in the world which can carry a position in extended order, it is the English infantry. I am decidedly as entirely and absolutely opposed to anything like slavish copying as it is possible for any one to be. I am opposed to it, not because I have any false pride about learning even from an enemy; it is quite the reverse; I should have no objection at all to learn from anybody. But I do think copying is apt to take the spirit out of a

* Instances occurred in 1866 which are mentioned by Captain Laymann in his pamphlet "About Tactics."

† Compare Boguslawski, p. 73, German edition.

thing. It reminds me always of a circumstance that occurred in my own experience in India, where a brother officer engaged a boy to run messages, and gave him a suit of livery, part of which consisted of a large brass plate, with his name upon it. The plate had to be engraved with his name, and in order that it might be done by a native artist, the name was written on a piece of paper. Unfortunately, the writer got hold of a very bad pen, so that the name was adorned with certain "sploshes," which were faithfully reproduced on the brass plate. I think if we are content with simply copying the system of any other army, the probability is that we shall copy the "sploshes" as well as the good points.

The CHAIRMAN: We are very much indebted to Major Jones for the lecture that he has given to us this evening. The discussion that has arisen has been very instructive and suggestive to us. I think you will the more readily join in the vote of thanks which I propose when I tell you that Major Jones's engagements at Sandhurst have afforded him very little time to prepare his lecture or to deliver it. I therefore venture, on the part of this Meeting, to return our best thanks to Major Jones.

LECTURE.

Thursday, July 18th, 1872.

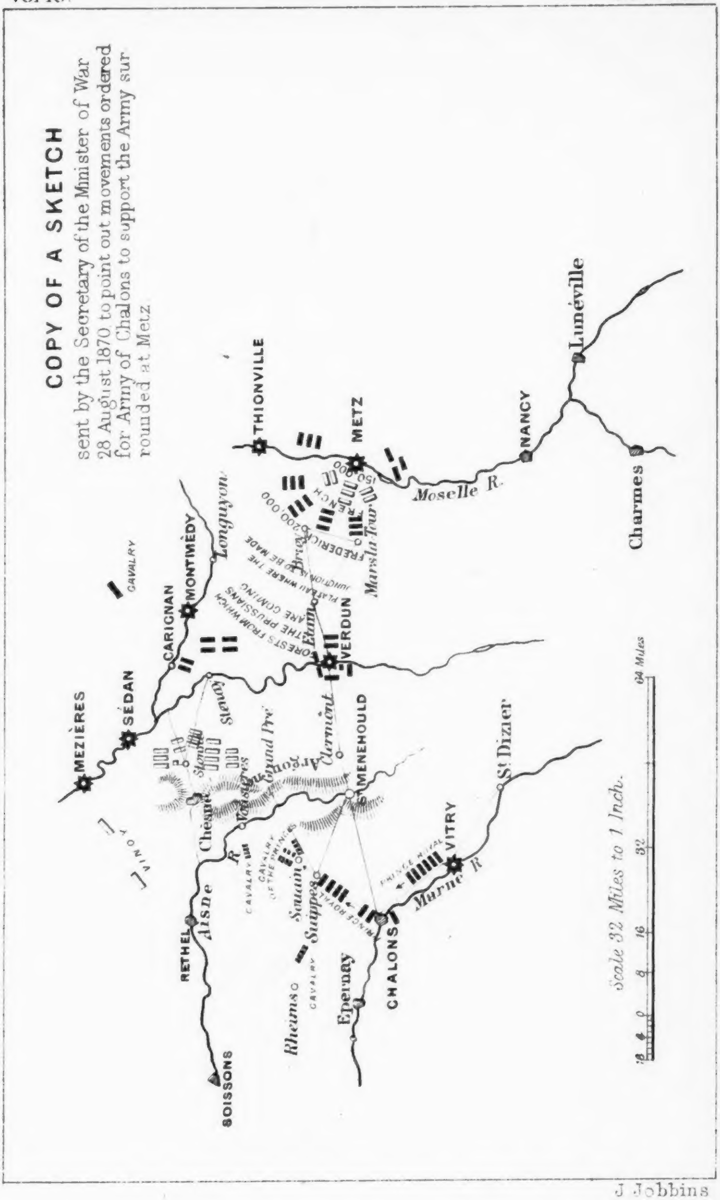
FIELD MARSHAL H.R.H. THE DUKE OF CAMBRIDGE, K.G., &c., &c., Commanding-in-Chief, President of the Institution, in the Chair.

THE THEORY AND PRACTICE OF PEACE MANŒUVRES, WITH THEIR RELATION TO REAL WARFARE.

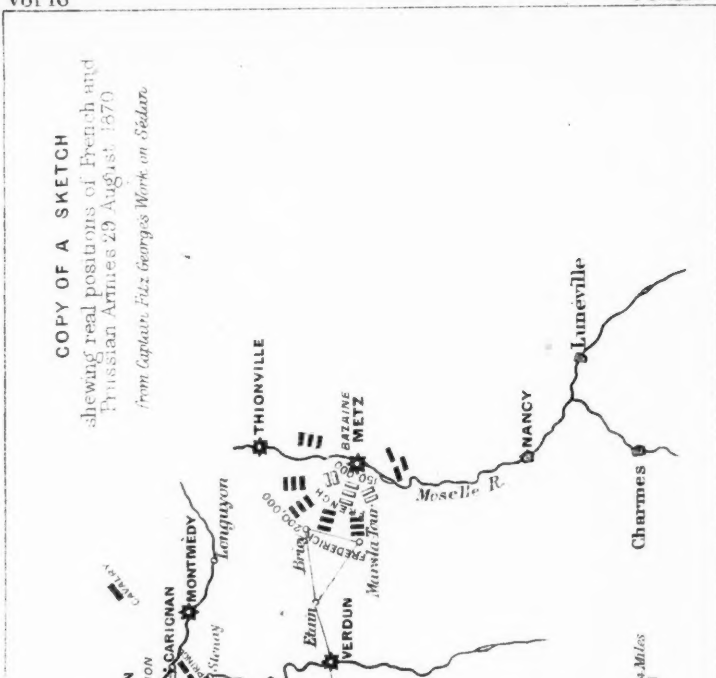
By Lieut.-Colonel C. C. CHESNEY, R.E.

BEING abroad on duty last year when the manœuvres near Aldershot were carried on, I cannot affect to be as conversant with their details as many others are. But my loss was in part at least compensated by the advantage of hearing the subject discussed in its widest form by many men of different nations and various views. Having been invited now to lecture upon it, I propose to lay the results of these discussions before you—not without some personal misgiving as to how my remarks may be received by the world outside. For I shall have to combat very popular fallacies, to expose some false yet attractive theories, and to dispel certain rose-coloured but baseless visions which eloquent writers have raised both in and out of the ranks of the Army. It is impossible to tell the plain truth on the subject of these "Autumn Manœuvres" and the limits of their value, without giving offence to some of those who expect from them what they can never produce. But the truth ought not to be kept back, nor the nation be left under any delusion on a very plain matter. I only ask, by way of preface, that I may be believed when I say that not one word of the opinions now offered is the consequence of any humble and mechanical connection of my own with those now preparing for execution. It is not this, but long and earnest reflection on what I have seen and heard on the general subject from those of greater weight, knowledge, and experience than myself, which induces me thus to speak.

It was a practical military man whom we all respect that quoted approvingly in his recent lecture on "Autumn Manœuvres" at this Institution the words of an eminent living authority, "There is nothing "so unlike a real battle as a sham one." Far from disputing this opinion, it is my purpose to enlarge greatly upon it. I would en-


COPY OF A SKETCH
sent by the Secretary of the Minister of War 28 August 1870 to point out movements ordered for Army of Chalons to support the Army surrounded at Metz.
THIONVILLE
METZ
NANCY
Lunéville
Charmes
Moselle R.
Longuyon
MONTMÉDY
CAVALRY
CARIGNAN
SEDAN
MEZIÈRES
Stenay
VERDUN
Etain
Briey
Mars la Tour
FREDERICK
FRENCH
200,000
150,000
FORESTS FROM WHICH THE PRUSSIANS ARE COMING
PLATEAU WHERE THE JUNCTION IS TO BE MADE
Clermont
Argonne
Grand Pré
Vouziers
Chesne
MENEHOULD
St Dizier
VITRY
PRINCE ROYAL
Marne R.
CHALONS
Suippes
Souain
CAVALRY
CAVALRY OF THE PRINCE
Rheims
Epernay
RETHEL
Aisne R.
SOISSONS
Scale 32 Miles to 1 Inch.
0
8
16
32
64 Miles

J Jobbins


COPY OF A SKETCH
shewing real positions of French and Prussian Armies 29 August 1870
from Captain Fitz George's Work on Sedan
MEZIÈRES
SEDAN
MC MAHON
CARIGNAN
MONTMÉDY
CAVALRY
Longuyon
Stenay
Stonne
Chesne
THIONVILLE
BAZAINE
METZ
150,000
200,000
Briey
Mars la Tour
Moselle R.
NANCY
Luneville
Charmes
VERDUN
Etain
Clermont
Grand Pré
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Vouziers
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RETHEL
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St Dizier
Epernay
Rheims
SOISSONS
Scale 32 Miles to 1 Inch
8 4 0 8 16 32 64 Miles

J. Jobbins

deavour to show that the truth it indicates underlies the whole work of the soldier in time of peace; and that whatever pains he may take, and whatever advantage gain for his service by his labour, he cannot approach the dread realities of war, nor do away with the necessity of going for his chief and most useful lessons to the only correct source of military knowledge, the history of what man has done when subject to the conditions of mortal contest with his fellow man. In short, as it was my business last year, at the call of this Institution, to show how the study of military science in time of peace has been one of the chief means used to develop the efficiency of armies, so it is proposed now to follow the same idea out more in detail, and to indicate the danger and difficulties which of necessity await those who imagine that any study however diligent, conducted independently of, and without reflection on the unreality of peace practice, and on its divergence from the facts of history, can possibly be a substitute for the experiences of war and the lessons they bring with them.

The very title of this address points in the broadest way to the distinction which must ever exist between real and mimic war. For look at the former, with its stern use of patriotic sentiments and personal ambition, its hazardous combinations, and unforeseen issues. Consider for a moment the absolute dependence of the best laid plans of the most consummate leader for a successful issue on the faults and shortcomings of an adversary, whose means and mode of action he can hardly guess at, far less control. Mark the untrammelled power with which the military head is clothed under the martial law, which, as our own greatest soldier epigramatically said, "means the will of the "General." And then turn to the uses of peace warfare, even as conducted under the most powerful administration, and you will discover at once that in it are altogether missed, or are but very feebly represented, the most powerful motives and the most frequent contingencies which effect the results of real campaigns. Hence it is that while theory and practice may go so far apart in war that the one may scarcely be known to have resulted in the other, the theory and practice of peace manœuvres cannot, or at any rate need not, thus be separated. In the latter the strings all converge to the same point, and are under the same final control; in the former the whole issue is often as much beyond the actual power as beyond the mental ken of the designer. Let me illustrate this last truth by a forcible instance from facts within the memory of all of us.

On one side of the space before you hangs a plan which is an exact reproduction, save for necessary enlargement, of a theoretical design sent out for execution early in the late war. The fatal days of August 1870, had already broken down almost to ruin the military prestige of the Second Empire. Napoleon's best soldier, the brave old Marshal of Magenta, whose chivalric and unselfish character still makes his name as popular with the French soldiery as in the heyday of success, was rallying at Chalons the wreck of the Army rashly risked against hopeless odds at Woerth. Bazaine too long delaying or delayed on the Moselle, was known to have been actually intercepted in his attempt to retreat from Metz, and the fine words which Count

Palikao used to the Assembly, whatever he meant outwardly by them, did not conceal from himself and his trembling colleagues the desperate nature of the situation. To extricate the Army of the Rhine from the net that Von Moltke had thrown round it, seemed to them the only help in a military or political sense, and their plan for accomplishing it, as well as their view of the general situation, are made clear at a glance by the sketch to which I am pointing, which is enlarged from that drawn in the bureau of Palikao to guide the Commanders concerned. Observe the situation of the German Armies, indicated by no means incorrectly, but the Army of the two Crown Princes, represented as wheeling just too late to intercept MacMahon's march across their north. Observe, too, that the designer is aware both of a cordon of troops on the Lower Meuse and of the presence of the armies enclosing Bazaine. Only he clearly supposed in his own favour the solution of three several difficulties which lay in his way. The Army of MacMahon was to slip past the main body of that of the Princes; it was to break with ease through the cordon of troops on the Lower Meuse; and it was to produce such an effect on the blocked-in force round Metz as to render it certain that Bazaine could push his way through and effect the required union near Etain. Surely in all history there is no more absolute contrast between theory and fact than is shown in the difference between that plan and this, which is taken from the work of Captain Fitzgeorge, to illustrate the facts as they actually occurred. Surely Palikao could have written no satire more powerful on his own ill-conceived and worse executed design than is contained in the simple words scratched on the plan that left his office, "Plateau where the junction is to be effected." Need I recapitulate to any one here the story of those disastrous days which followed the sending out of this sketch on the 28th August, 1870?—the annihilation of MacMahon's Army; the repulse of Bazaine's; the almost miraculous escape of Vinoy, the third concerned.

But what I would bring to the special notice of this audience is that, supposing—which is quite beyond any reasonable supposition that should be made, except for argument's sake—that any nation went deliberately to the expense and trouble of practising great strategic movements like those which culminated in Sedan as peace manœuvres. Supposing, in short, that Palikao had had in his bureau at Paris the final control of the action of all the Commanders concerned, would the events have been in any way like those which history has now recorded? Would one army have been ill-supplied, mutinous, and irresolute; the other well fed, cheerful, and vigorous? Would one Commander have been allowed to overreach and anticipate the other, or his troops to cover twenty miles of ground a day against the other's twelve? Would Bazaine with four corps have fallen back on the 1st of September before one and a half, leaving his work of self-extrication undone for want of serious and sustained effort? The answer is, indeed, too obvious. But the moral of the whole, as I read it, is that no peace practice could in any way match the teaching of war on the grandest scale, for theory in the former overrules and constrains the conditions of practice, which in the latter lead the whole course of

events, and in the end decide the result; and if you descend to smaller instances you will but find the same contrast. To teach strategy by peace manœuvres would, even in a modest way, be a frightfully expensive process, as I shall hope to show at a later part of this lecture. It would moreover be tedious and uninstructive to all those concerned save the two or three heads in the secret of the operations, since their part would lie chiefly in long and steady marches; and when taught, or supposed to be taught, it would have been under conditions so different from those of real war that it would be a delusion to think it had made even one good General to add to the national security. But to this subject it will be necessary to revert to more particularly by-and-by.

That of tactics, if not so attractive to the student, can at least be made more intelligible to the general reader, and on that I now propose to dwell at some length; and in tactics it will be found that the rule holds good quite as much as in strategy, that peace practice never will, never can, supply the place of the study of the events of war. Nay, it is possible, keeping strictly within the limits of absolute fact, to state unhesitatingly that no troops or staff, however experienced, can ever be got to conduct their actual contest in mimicry with full attention to the conditions of war. In brief, they never could be so unless one necessary order were given, which even in these days of strong opinions and bold proposals we still hardly hear, namely, to load with ball-cartridge. Those who propose to make a real battle with sham ammunition, and to reason seriously on the lessons it affords, are but preparing disappointment for themselves and those who listen to them. The deep truth holds as good as ever, that in war the moral force is to the physical "as three to one," and when you eliminate from your conditions of battle three-fourths of the whole working power which leads on to victory, such victory as is won can hardly, with any justice, be deemed real enough to be worth the winning.

Lest I be here charged with theorising, I turn to support my statement by certain facts reported recently in his lecture given here on "Autumn Manœuvres" by Sir William Codrington, as witnessed by him in the sham fights of those in Germany in 1869. Here—and I pray this point may specially be noticed—there was no untried Army or inexperienced staff. The cadres at least, with their chiefs, had lately made the victorious campaign of Bohemia, and triumphed over the hardened warriors in whom Benedek and his Emperor had trusted. Moreover, autumn manœuvres had for forty years been practised by the Prussians as a speciality. Their Officers had studied them. Their drill-instructions prepared for them. All conditions seemed to point to at least some approach to reality in the sham battles that were to be conducted under such favourable circumstances. And yet what did the witness of them observe? Artillery playing steadily on regardless of the skirmishers, 400 yards off them, who would have put the battery *hors de combat* in five minutes; cavalry standing still exposed to the same supposed destructive agency at 250; infantry pouring volleys at each other within 70 or 80, the "whole accompanied by many impossibilities, and the fighting the

"more unreal as it became closer." Such are some of the expressions I find recorded in notes taken at the time from the narrative delivered by a keen and practised observer. Not that anything here said was said in disproof of the utility of such manœuvres; on the contrary, their value was confessed, but the unlikeness to real war was maintained by Sir W. Codrington, as it probably would be by every thinking man who thoroughly weighs the matter.

Peace Manœuvres cannot teach even good soldiers fully what they have before them in war.—This broad statement—my chief proposition to-day—I hope to prove beyond dispute from the tactical lessons of the late war as now read, and their conflict with the theory of fighting as it was among the Prussians before they had been duly learnt. I trust I may be pardoned the necessary digression for treating fully this important matter. It is true that even now the Germans have not wholly conformed their favourite tactical teaching entirely to the facts they have witnessed, but the latter are so widely admitted that it is but a question of time when it shall be made the rule to act in conformity with them, instead of it being left an exception to be adopted at the will of individuals when circumstances press, under the general freedom of action allowed to German Officers. The point now to be demonstrated is that the knowledge gained is in opposition to the theories used in their peace practice.

There have been during the last century, it may here be briefly stated, but two men who, by the innate power of genius, aided—pray mark the condition—*by the use of its exercise in the field*, have pierced through the coming years with true insight into the spirit of the tactics of modern warfare. Both of these soldiers of prophetic spirit were Prussians.

Eighty years lay between the eras of Bülow's and May's predictions, and in that long interval arose, culminated, and set the star of the mightest warrior that the world has ever seen. Yet great in organisation as he was, in strategy peerless, Napoleon has left no record to show that he foresaw the day when a change in tactics should come suddenly in as great as that with which—chance-found by them, as the secret seemed to be—the revolutionary armies of his early days had met the stiff lines of Frederick. This is the more noteworthy, because it is well known that he was aware of the remarkable saying of Bülow, a saying obviously the result of profound meditation of the peculiar fighting, much of it in cover, he had witnessed in the American war, that "the day would come when armies would be resolved into individual skirmishers."

Bülow said other things as startling and more unpleasant than this in the ears of the paternal government under which he lived, and found the reformer's reward of the day in a prison cell, where he died before the efforts of Napoleon, who alone of his contemporaries recognised the genius of the obscure essayist, could avail to set him free. Bülow's words would have been perhaps but little noted but for his sufferings and the French Emperor's interest in him.

His fate however caused him to be remembered, no less than his keen sayings. His brother too, rose to high command and honour

in the army to which the ill-fated writer had belonged, making the world familiar with the name of Bülow in the great struggle which culminated in Napoleon's overthrow. And when, long years after he had stood by our side at Waterloo, the startling effect of the rifled musket in increasing the power of skirmishing was seen at Solferino, the words of his relative, the old Prussian writer, came back to thoughtful men, and made them marvel at the precision which had marked his utterance of an opinion so strange in the ears of his generation.

The breech-loader succeeded the Minié, and Nachod and Kœniggratz came to blot out of history the lesser triumphs of Magenta and Solferino. The Prussians reaped the full advantage due not to autumn manœuvres, nor any other form of drill, but to their perfecting the national organisation for war in the light of the miscarriage on the Rhine in 1859, and to their putting improved arms into the hands of soldiers educated to the point of using them wisely. Almost at every point they triumphed, prepared for victory by the moral superiority which their trust in their weapon gave, and led with a freedom and vigour which only a liberal use of what was meant to be an exceptional part of their older drill could have imparted. Von Moltke, here plainly going before his brothers-in-arms, had publicly counselled in 1865 a freer use of the new famous Company Column than had hitherto been allowed, and his advice was largely followed in the war with Austria, so largely that in the eye of many of the older school of Officers the result was a tendency to disorder. Steinmetz for one, it is known, would not permit his corps to be scattered into these small units so constantly pressed into service elsewhere.

Triumph followed however on triumph, whether the half battalion which he preferred, or the company column, was favoured for the development of the new order of battle. The world looked on and admired the effect, not yet understanding the process. Even those engaged in it were apparently unaware how far their method in practice went beyond the utmost limits of the drill-book, and spoke of the company column as the key of their success with the same belief in its infallibility, and of the impossibility of going beyond it, as any Peninsular warrior ever boasted of Wellington's line.

But this belief was not to last long. From among the ranks of the victorious army arose one whose voice was soon heard and recognised throughout Europe as the true seer of the military visions of his time. Here was one who belonged to those who had achieved the most remarkable tactical success of modern days, and yet, far from being satisfied with what had been done, he boldly treated it as mere proof of the necessity of that complete tactical reform for which he longed, and which in his *Tactical Retrospect* he declared certain ultimately to be carried out, though for a time it might be introduced and then again prohibited. "The extraordinary extension of front with a very small depth," "the confused irregular attack," "the wide stretching-out of the wings," of which Captain May wrote as characteristic of the fights of 1866, he declared were not to be condemned as faulty, but to be utilised as part of the future system. "An army," he went so far as to say, "which cannot venture to trust in the individual worth of its soldiers, cannot

reckon on the advantages of the breech-loader." As he wrote these words, and proceeded to illustrate their truth in detail, the French were busy arming themselves with a better weapon than those he had seen in action; but as though the prophetic mood grew on him with his task, he closed his work with the declaration, that in the wars of the future the decisive element would be intellect, not only on the part of the leader, but down to that of the last soldier, and he added the fine prediction that the path of progress in civilisation was that which would make a nation invincible in war. If he be right—and it is well said that his work rather foretold the future literally than, as was its professed intention, criticised the past—then we must reverse, when we think of war, the Laureate's saying, that "the individual withers, and "the world is more and more," and allow that the importance of the individual and his training for personal action—of his whole military education, in fact—is far beyond that which it could have been when the serried line or the steadily moving column, in which each unit could feel his fellow soldier's touch, were the chief means of using the power of the musket.

This digression would be by no means complete for its purpose without putting before my hearers the facts of the late war, as they are represented by indisputable authority, so that it may be seen how little peace manœuvres, such as those of 1869 already spoken of, aided the Prussians in solving the terrible problem before them. It was not by the bold tactics so easy under fire of blank cartridge—not by the direct attacks over open ground on positions well held, which seem to have been rather the rule than the exception in the sham battles witnessed by the foreign visitors in East Prussia—that MacMahon was overwhelmed at Woerth and Bazaine crushed at Gravelotte. The character of the real fighting of 1870 showed an individuality which has impressed itself on all who studied it: and one writer especially has brought its peculiarities out into the clearest light by able generalisation from the facts witnessed by himself and his brothers-in-arms. Need I say that I allude to the work of Boguslawski, that diligent follower in the art of tactical reform of Bülow and May, as well as, it may be added, of Prince Frederick Charles, whose famous essay, the "Military Memorial," has probably had more to do with the achievement of the favourite object of the royal writer, *How to beat the French*, than all the sham battles that the sandy plains along the Vistula ever witnessed during the forty years of peace bequeathed by Waterloo to Prussia. Following out the design of bringing before you what fighting really became eighteen months since, when both sides for the first time carried the breech-loader, I turn naturally to the work already mentioned, happily just translated into our own tongue by Colonel Graham, and so brought within the reach of all. Boguslawski cannot claim the prophetic vision of Bülow, nor the words of fire which made May's work a landmark to the soldiers of his age. He has not, like Prince Frederick Charles, shown the power of applying military theory to the solution of a special national problem. Yet, as a plain practical soldier, writing he tells us, from the ranks, and describing what really happened in presence of himself and his

comrades, he is even more valuable for our present purpose. His work has been already read all over Germany, and would have been contradicted a hundred times over did it err in any vital particular. We may say therefore what we please of its lessons. They may be held applicable only to Frenchmen or Germans, only to men of particular race or of special training, yet there they are before us in letters that all who run may read, and however little we may approve of deductions made prematurely from them, as facts at any rate they are too important to be neglected. We will go straight for our purpose to his closing chapter, a sort of summary of the rest of the work.

The tactical action of the three arms together in the field he declares was so excellent in his service that the keenest critics could find in regard to it but little with which to reproach the German Army. Small exceptions indeed may be taken here and there; but they are worth no special notice save from the class of writers who will be positive on every point. From this subject, therefore, he passes on rapidly to the study of the peculiarities of the new order of battles created under the influence of the breech-loader, and to the distinctions noticed between this and that of the days of the First Napoleon.

All direct attacks on a good position must now-a-days, as a rule, be at first repulsed. Assuming this as an ascertained fact, there arises from it the necessity of outflanking the enemy, and this supposes usually a superiority of numbers. With troops of equal quality he observes, however fine the leadership may be, grand strokes of tactical success won with the lesser force are not henceforward to be looked for. For the same reason outflanking to win has become as normal a type of victory in the battles of the present day as the breaking through the enemy's line in those of Napoleon.

The character of the ground to be fought over is at least as important, if not more so, than it was sixty years since. It is probably even more necessary, now-a-days, to possess oneself of its commanding points, for whenever won, artillery fire from them searches a larger space of the field, and it is easier to hold them against counter-attacks than in days before the breech-loader came into use.

As to the actual course of the fight itself, it is opened much as formerly, with artillery fire and isolated attacks on advanced points. But as the artillery contest becomes warmer, a decisive departure from old forms comes into operation, the attacking force striving only to play with the enemy's front, whilst certain corps, told off for the purpose, spread themselves out beyond the wing about to be turned, the cavalry being usually kept well behind, and probably on the flanks. Instead of the decisive attack being now made in large columns covered with skirmishers, and probably culminating in a grand bayonet charge on some important point of the enemy's line, possibly his very centre, it now takes place on the threatened flank with dense swarms of skirmishers, followed up by small supports, preceded by artillery fire, and gaining ground apparently slowly. But if the position be actually turned and carried, the quick firing on the retreating enemy, which forms the pursuit in these days, will be so dreadful in its effects as to make his defeat far more severe than a successful attack of the heavy brigade or

division column sixty years since. Often the cavalry will not come into use at all, and even when taking up the pursuit its action will be limited by the still powerful fire of the retreating foe. As to reserves, which formerly had the all-important part of deciding the battle, they have now to be kept so far off that they will not unseldom be too late brought into action at all. So much for the offensive side. As regards the tactics of the defence, the new order of fighting requires that the front line should be made very strong and held at any cost, whilst the reserves, no longer in their old place behind the centre, must be kept in rear of the wings, and constant reconnoitring beyond each of the latter be employed to discover any turning movement of the adversary's as speedily as possible, and meet it by their agency. In short, where concentration for the attack was the rule sixty years since, with the German Generals it has now become extension. And for this there is a double reason—the impracticability of carrying a position properly held with breech-loaders by a front attack, and, which is quite as important, the facility which this terrible weapon, the breech-loader, gives to an apparently extended and thin line of repulsing the counter strokes with which a General of skill in Napoleon's day would have fatally broken through the army that had dared to stretch out to attack him in the modern German fashion.

Boguslawski adds some interesting details of the special changes wrought by the new arms in the use of cavalry and artillery, but he excuses himself for giving his chief attention to the infantry; since the immense losses the latter suffered proportionately to the other arms show how much heavier were its duties than theirs. It has proved itself more than ever the decisive arm; and it may be excused (he adds) if in tactical perfection it appeared not to quite come up to the adroitness of the others, its task being really the more difficult. And in finally considering its special tactical form as now used, he declares it may be comprised in the words, "great swarms of skirmishers and "small tactical units." The experiences of 1859 and 1866, he adds, foreshadowed this; those of 1870, with the breech-loader on both sides, made such a rule absolute. The very notion of leading heavy close masses to the assault, or deploying them to fire volleys in line, is entirely put aside. The individual power of the soldier, and that of the Officer to control and guide him in the fight without losing the advantages of this independent action; that is the quintessence of the new form of infantry battle. If Boguslawski be right, the line and column controversy is settled, so far as his own nation is concerned, by leaving the uses of both in action entirely subordinate to that of the skirmisher, if indeed they be not wholly got rid of. He admits candidly there are certain exceptions to this sweeping rule, but, as a rule, maintains its truth, and declares that the terrible effect of the modern small arm fire practically enforces it, so that he has seen whole brigades dissolved into skirmishers in some of the hard fights of the late war.

It is of course open to us to question the application of these remarks to other Armies. It is certainly not in Germany that the conclusions of the writer are fully adopted; for, among his closing recommenda-

tions, are that all movements done in close order should be treated as exceptional; that skirmishing should be taught a recruit almost from his first day, *pari passu* with his other exercises; and again, that skirmishers and supports must alike be trained to intermix with those from other companies or battalions, and to act under the orders of the nearest Officer as readily as though he were their own, just as necessity compelled their doing in the tougher contests of the late war.

It will not be out of place here, to add parenthetically, that much of what is so remarked on, and so strongly recommended just now by the victorious Germans as the key of good skirmishing, appears to have been familiar to the best of our own Peninsular Officers. Anyone who takes the trouble of studying the paper of *Advice on Drill*, written by Sir William Napier for the Volunteers shortly before his death, and largely quoted from in General Macdougall's work on *Modern Warfare*, will at once discover that the principles of combined freedom and discipline were applied in the very same manner by the old soldier-historian, from his practical knowledge gained with the 43rd Light Infantry, as they are in the most recent German work on tactics.

"I told off my men," he says, "by numbers, and practised them to "suddenly run back or advance in the most confused mobbish manner, "either to rally readily or seize an advanced position. The first man "who arrived at a rallying place served as a point on which the others "formed without confusion * * * My command "would be, 'Soldiers, do you see the enemy's skirmishers advancing to "'that hedge, bank, ditch, rock, whatever the thing might be? Yes! "'Well, forward at speed and seize it before them.' In an instant the "race and emulation fired them; they used to dash forward furiously "even on parade, and in battle generally gained the ground first. With "this practice your men will soon acquire an eye for good cover, and " * * * will be good skirmishers, provided they "are first taught by other more mechanical drillings to understand "their business as soldiers, and very little will do that." Again, "Suppose you are outnumbered and the enemy begins to outflank "you, your reserves must move out rapidly to advance and oppose "them; but suppose you have no reserve, you are outflanked, you "retreat," words which, though published before the two great and successful wars of the Prussians, contain the very pith and marrow of what the victorious Army has learnt. Indeed, excluding—what is here purposely omitted—Sir W. Napier's check on irregularity by teaching men always to form into their numbered places, as judged unnecessary by German Officers for thoroughly disciplined troops, one might take these instructions, with General Macdougall's just comments on them, that "the secret of success in light infantry movements "is to obtain the speed of irregularity and yet to divest it of con-"fusion," for passages from Boguslawski's earlier chapters and the repetition of them in his closing summary. Where practical soldiers of different nations meet so closely as here, their joint conclusions should be indeed well worthy the study of all military men to whom the improvement of their profession is dear.

But such discussions would carry us beyond the present purpose.

which is to demonstrate that no peace practice of any kind can be hopefully adopted for the purpose of working out the true solution of tactical problems. To put this proposition more plainly. Can any one doubt that it would be perfectly possible to train two bodies of picked British troops, and that without any very long notice, so as to manœuvre against each other at the word, either in simple line and open column, as in the days of Frederick, or line and column with skirmishers, as has been the universal mode from the Revolutionary wars down to our own day, or in the company columns first recommended for more general use by Von Moltke seven years since, and to make in either case interesting sham fights, imitative, if you pleased, of certain well studied actions? But who will pretend to say that any quantity of such practice, carried out with blank cartridge, would possibly avail to tell us whether the Germans were right or wrong in passing on from all these forms to adopt one, in which practically every soldier engaged fights in looser and freer order than any seen since the Romans conquered the world's empire for Rome? For they claim to have established a new order of fighting in which the touch of the next file and the confidence it brings are replaced, as among the Romans they so closely imitate in their training, by the individual power of the soldier and his special dexterous handling of his weapon and complete subordination to his officer. General A and General B might practice sham fights against each other for a twelvemonth out of any drill-book given them to work from, and if one be more ready and dexterous than the other, he may find fair occasion to show it. But such problems as that indicated above can only be solved when the breech-loaders send forth their bullets; in other words, they must be studied from real war and not from peace manœuvres. Too much altogether is expected from these for tactics as well as for strategy.

It was but lately, for instance, seriously proposed to attach assistant umpires to all the batteries, who should have power to send off the infantry fired on at long range. Why everything in such cases as these depends on circumstances of which no umpire can fully judge. The most striking differences occurred during the last war in practice from slight alteration of the conditions. At Mars-la-Tour (as we know from the letter of a French Staff Officer read here, on the 24th ult., by Captain Henry Brackenbury) the French 93rd found it impossible to advance deployed in line in face of a heavy battery which struck them down by hundreds, at a distance said to be 3,000 metres. From recollection of the ground, I believe this distance overrated; but the French were on the face of a gentle slope, and so exposed to the full impinging action of the percussion fuze. On the other hand, at Gravelotte thousands of the German shells flew harmlessly over the French as they lay down behind the slightest cover raised or found existing along the crest of the hills they held on both their flanks. The famous walls round St. Privat are as slight erection of loose stone as ever sheltered musketeer. What umpire that would not have ordered Canrobert's troops away, had the fight been a sham one, when ninety pieces raised shell concentrically over the heads of the slender force which held the enclo-

sures? And yet it is admitted that the position was fairly maintained until want of ammunition and the absence of all supports from the reserves shook the confidence of Canrobert's men. Such attempts as that indicated to imitate nature by giving off-hand decisions on the effect of distant fire, would be but to add new difficulties to the old, and to prepare fresh disappointment for those who are so sanguine as to hope to draw from mimic war all the lessons soldiers need. In brief, troops can be trained, and their training largely improved by peace practice, or any given form of tactics; but *the reform of tactics comes by the study of war.* Even Von Moltke's recommendation to develop the use of the breech-loader by developing the use of the company column came after his Danish experience: it may be added that despite that great soldier's foresight and genius for war, his countrymen tell us they have already, under the pressure of two great contests, bettered his instruction, and left the recommendation far behind.

Enough has been now said of the limits which restrict the study and practice of tactics in peace. As to the vaster operations of strategy, your attention has been already directed to the fact that even were the expense of attempting any such so limitless as to put them for our purpose beyond any sober consideration, the result would but be painfully and dangerously misleading. The theory of such a science cannot be worked out with any regard to peace estimates; nor if the restraint which these impose on all responsible rulers were transgressed would the results be at all commensurate with the sacrifice. That this is so has been already sufficiently explained at the opening by a special case taken from the events of Sedan, and this might be repeated indefinitely with the same result of demonstrating that the calculations made for two armies in a single cabinet are in their issue most unlike those made in the opposing councils of two hostile powers. In the latter case only can the real forces which are to produce success or defeat be sincerely brought into play; and it is from such that real lessons are to be gleaned, so far as experience and study can be trusted at all to teach the highest of military sciences.

But it will here be said that those who demand that strategic problems are to be worked out in our peace manœuvres are speaking rather of such as can be managed on a much smaller scale, such in fact as approach in character the minor operations of war rather than those that belong to the higher portions of strategy. It will be our next object therefore to show that the demand, even when put thus moderately, is hardly a well-considered one, and is in truth little more practical than the wildest scheme of a closet theorist for working out an Austerlitz or Waterloo with peace armies. The shortest proof of this may be found in the fact that neither in Prussia, where the system of autumn manœuvres boasts sixty years' standing, nor in Austria, Russia, Switzerland, or Italy, in all of which it has of late been adopted, is there the least pretence of the practice of actual strategy. The same reasons which practically forbid it to ourselves forbid it elsewhere. A few marches to fixed points of collision: sham engagements between two parts of the Army, or the attack of a sham enemy by the whole; movements carried out under general ideas promulgated from

day to day, and therefore necessarily restricting the Commanders to very narrow limits; such are the constant features of these mimic campaigns. Analyse what has been publicly written or said of any of the most recent operations of this kind in Prussia. Study the valuable account of last year's Russian manœuvres contributed by Colonel Money to the *Times*. Search the reports of the Hungarian gatherings of regulars and Honveds last year before the Emperor Francis Joseph—an experiment almost as bold as our own admixture of the line with the auxiliary forces. Read (as many here may have the privilege of doing in the official copies) Major Stotherd's instructive narrative of the Italian peace campaign of last autumn. Question—and this I have done very thoroughly in person—the Swiss staff, as to their own experiences with the Militia which forms their only army. In all or any of these examples it will be found that the limits of action are modest and confined far more than many of the ready writers of our journals appear to be aware of. They are in fact no higher or broader than has been already stated. And the reasons for this are not far to seek, though to put them clearly before you a little detail is necessary, the statistical part of which shall be made as little terrifying as may be by being reduced to a brief abstract, which is drawn direct from the best authority.

The pith of what has to be said here is given by Colonel Hamley with his own unrivalled clearness in his work on "The Operations of War." "Two armies," he says, in his chapter on Supply, "are not "like two fencers in an arena who can shift their ground to all points "of the compass; but rather resemble two swordsmen on a narrow "plank that overhangs an abyss, where each has to think not only of "giving and parrying thrusts, but of keeping his footing under "penalty of destruction. The most unpractised General *feels* this at "once on taking command in a district where his troops are not sup-"plied by routine; or if he does not, the loss of a single road to his "Army"—pray mark these words attentively—"would sufficiently "impress it on him."

Now if this be the case with an army in time of war—if "the will "of the soldier," as great technical writers phrase it, be so important an ingredient in the General's calculations when the pressure of real combat places supreme and instant power in his hands, how much rather must this be the case in time of peace? We shall revert to this subject again. For the present it will suffice to say that the designers of peace manœuvres must bear in mind, certainly not less than genuine strategists, the absolute necessity of the integrity of their supplies.

Now we have heard a good deal of proposals for carrying on our manœuvres so freely as to allow the capture of supplies. Have those who talk of such things seriously considered what the words used signify? For some one to capture supplies means that some other is to lose them. And not only would the troops losing them prove very troublesome and unpleasant to handle, if what has been said by Colonel Hamley and others who study the matter has anything in it, but there is another restraining cause of vast weight ever present with our peace operations which absolutely forbids our running the risk of

leaving any part of the forces without food or firing for a night. I refer of course to the omnipresent power of the press.

I should be the last person to be slow to acknowledge the immense benefits our Army has derived from that great estate, against the watchfulness of which some of my profession idly chafe, as though it were all evil. It is common enough to say that the Crimean soldiers owed their rescue from prolonged misery, if not from actual starvation, to its beneficent action. And great gratitude is in truth due to what journalism then did for our comrades. But I would go much farther, and assert that it is in great part due to the intelligent interest aroused by it among the nation that we of the Army owe the fact that our profession has never from that epoch been allowed to sink back into any approach to those sad ante-Crimean days, when soldiers were too often regarded as good-for-nothing idlers, things to be hid away by small detachments in obscure barracks, without staff, equipment, or other training than could be given on a slip of ground between four bare walls, as though the country that maintained them was ashamed of its defenders. How this evil tradition arose in England, and why it lasted down to our own time, was a problem which, as all readers of Macaulay's History know, exercised the mind and pen of that great writer not a little. We need not pretend to touch it here. Enough for us that the mighty power of journalism, which some military men are wont to deprecate, has conjured it away with many other superstitions of darker times. Therefore we are greatly debtors to the press, we soldiers. Nor, indeed, should any honest public servant, civil or military, be afraid of fair criticism. But, on the other hand, when watched by such keen eyes as we must expect to be, we have to avoid the very appearance of blunder; and for this reason only, even were it not true still, as in Napoleon's time, that "armies march on their stomachs," we cannot, as before said, allow troops to be left, even for a night, unfed and uncared for. And this they would be too surely, if we played lightly at this game of capturing supplies, with its necessary concomitants.

But why not let the force fall back to get fresh supplies? Lest some one should go away supposing this simple question to be left unanswered, I will proceed to show why this is not likely to be practised. For any real strategic purpose then, such as is suggested by the question, troops cut off from their supplies by being outflanked, or allowing their communications to be cut, will be forced to retire—the proposition is self-evident even to a tyro—on to another line altogether. Now the mere feeding for 24 hours of a force such as is proposed to be put into the field this year from Aldershot of 15,000 men, with its proper complement of cavalry, artillery, and transport, involves the collecting the following supplies, taking last year's scale of provision as a guide:—

Food for Men.

	lbs.	
Meat	15,000	(allowing for waste and offal).
Bread	18,750	
Extra ration of bread for contingencies	18,750	
	52,500	
	450 cwt.	
	Or $22\frac{1}{2}$ tons.	

Food for Horses.

Cavalry and Artillery	2,700	
Transport	1,700	
	4,400	$91\frac{1}{2}$ tons.
Average rations for each: 15 lbs. Oats, 8 lbs. Hay		

Fuel.

Add wood for 15,000 men, &c., at average of 6 lbs. each ..	114
	$12\frac{1}{2}$
	$126\frac{1}{2}$
	Total weight of rations.

It follows that if the force is suddenly to lose its supplies, it should have over 100 tons of necessaries ready at the point on which it is to retire. But how is this point to be fixed? If the capture of supplies be carried out as a genuine operation, the General must not know from which side his opponent is to come upon him. He must, therefore, have a new set of depôts on either flank. And to continue the same line of proceeding logically, every separate halting place of importance within the area of operations must be properly garnished in case one or other of the armies is forced upon it. For it would be too late to make contracts for the troops when they were waiting to be fed; and if, for argument's sake, we were to suppose that they carry their bread and meat short distances with them, that is, they do *not* really lose their supplies (a supposition which of itself contradicts the theory), then you would still have to bring up from somewhere the greater part of the weight in wood and forage. To do this would involve the hire of 70 waggons a ration, or would cost at a probable payment of 35*s.* per waggon, £122 for every transfer of a day's supply, which would represent the pecuniary fine to be paid if the General retreating did not halt actually at a depôt. But this expenditure would be but a trifling evil compared

to the risk run of not obtaining cartage or supplies at all; a risk which carried out into actual fact once or twice would raise—who can doubt it who knows what a press is on such occasions?—such a storm of reprobation round the heads of the luckless authorities who had subjected the soldiers confided to them to unexpected want and suffering, as would almost inevitably result in the condemnation of peace manœuvres altogether.

And here it may be added, that those who desire that our forces should continue to profit by them, should be the last to risk their continuance by wild demands, compliance with which would put upon the War Department a burden of expense intolerable to the nation. To carry out strategy proper with peace forces could only be done, as just indicated, by forming depôts all over the country to be used so as to imitate the supplies which requisitions would produce in war; and to adopt this principle would raise the contemplated expenditure of about £100,000 to five-fold, ten-fold, or twenty-fold, without covering a sufficient area of country to meet the views of such projectors. But when this is said, all is not yet said. For if the nation and administrators were so wild as to try the experiment, the result would be doubly unsatisfactory. The greater part of the forces would be kept at marches to them apparently objectless and wearying, without the compensating excitement of real war to support them; and the half-dozen Officers trusted with the secrets on either side would carry out combinations, the true results of which at the points of collision would never be ascertained, for the reason already given, the unreality of all peace tactics.

To sum up the results of what has been said, the extreme limits of action in such manœuvres, as connected with the supply question, are, in fact, a movement forwards or backwards for a single day's march. Lest this rule should appear too stringent, it may be stated here that an analysis of all the recent peace campaigns recorded will confirm this to the most incredulous who is at the pains to make it. The most extensive impromptu movement made in any of these was in the Italian practice of last year, as recorded by Major Stotherd, when the defending force of General Longone suddenly fell back from Lonato, a march of nearly twenty miles, transporting its supplies with it, but making no lateral change from its line of operations.

Cooked rations carried by the soldiers are so favourite a device with those who plan campaigns on paper, that it will to many seem necessary to allude to them. Happily it is not needful to enter into a lengthy discussion of the subject here, or to offer an opinion of my own as of weight against the advocates of the experiment. It will be enough to lay before you what is said on this head in a recent article in *Blackwood*, which is well known to be from the pen of a Staff Officer who has seen real hard service as well as peace manœuvres, and who has an hereditary right to be heard on any matter that affects the name of our Army. A word from such an authority is worth an hour's theorising from those who do not practically know what men can and cannot do.

"It is quite true," says this writer (arguing against a proposal thrown out last year that the troops should carry their own food for

one or two days), "that it is occasionally necessary to order the troops "to carry their rations cooked with them, because it sometimes happens "that they cannot get in until late at night. But this is an excep- "tional case, to be met in an exceptional manner; and on the principle "that they had better on such occasions receive (what it practically "amounts to) a half-ration rather than no food.

"Every army has its own peculiarities, which it is in vain to contend "with.

"One of the most prominent ones of the British Army is, and "always has been, that to keep the men in health and strength you "*must* carry their rations for them, and issue them daily on the spot.

"And these national peculiarities are stronger than official red-tape "rules and the convenience of departments.

"Besides, there is little use in trying to diminish the burden of the "soldier's kit, if you simply more than make up the weight of his "necessaries and comforts taken off by heaping on his aching limbs "what the Control should carry."

It is vain, let this be said as plainly as possible, to chafe at the limits which facts impose. It is as absurd to complain that those who design a peace campaign have to study the daily necessities of the troops that are to be employed, as it would be to grumble that the men did not march thirty miles in a day because it is known that such a distance has been accomplished by a division under special circumstances. I have but slightly alluded to the consideration of expense, so closely involved in this question, for on this point most will agree with me that statesmen who are answerable to the Parliament and country are more likely to be right in their judgment of what is fit and acceptable to propose, than any irresponsible writer, however well-intentioned.

If, then, strategy cannot possibly be scientifically taught by peace manœuvres; if the tactical portions of these, however interesting, are of necessity so unreal that they cannot guide the wisest leaders as to the future; are we of necessity to conclude that the value of such practice is either none at all, or is greatly over-rated? Nothing can be further from our thoughts than to suggest any such solution of an inquiry as this. On the contrary, it is my firm belief that no other training, however careful, however intelligent, can wholly replace that gained by what, though it be but a form of exercise—or, if you prefer it, of drill—is so much the highest and most instructive form that all others should be regarded as designed to lead up to this large and more combined action of the army. To the fullest it will be found that our English writer is correct in stating at the opening of the *Blackwood* article, "The Autumnal Manœuvres did immense good; "and they promise, if regularly continued, to do more." In Italy, Major Stotherd's testimony, as gathered from the most experienced minds upon the Staff, is that the spread of intelligence among the Officers and men, and of subordination to authority noticed in the army of the young kingdom, is in great part due to the effect of such manœuvres. In Switzerland, I have been assured again and again, that the semi-volunteer semi-militia forces of the Cantons take an

interest in them, and go into them with a heartiness of spirit which is by no means universal in the isolated training of battalions that the law more usually enforces. In Austria the most unfortunate, and yet often glorious of armies, appears to hope more from them than has been gained by the bitter experience of defeat in successive wars. As to Prussia, the words of Boguslawski on this subject express the general sentiment of her Officers :—

"For the last sixty years we have, fortunately for us, held to our "peace manœuvres. Every one now admits that it was owing to "these that our Officers and soldiers gained during the long peace an "impression, as nearly correct as was possible, of war, and made at "least an approximate acquaintance with the actual hardships of "warfare, and with the art of making themselves at home in a strange "country upon bivouac."

It is hardly necessary surely to add to this weight of opinion; but I beg those who still doubt to remember the fact, all-important to the moral tone of our Army, that these manœuvres are absolutely the only training troops ever can have which will enable Officers thoroughly to know and be known by their men. For these two classes may spend a lifetime side by side in barracks, and yet come out of that experience utterly ignorant how far the one can rely on the other in the field. Does any one suppose that before the late war there was a single Officer so cognisant of the sad state of the French infantry as to be prepared to learn that on the first day's retreat of Douay's corps—the enemy being not only unseen, but at the time a week's march from them—700 of his infantry threw away their arms? No wonder that his Staff blushed when not many days ago after they found themselves at Chalons, the Aldershot which the French army had made the measure of its highest practice, and remembered how often they had trod its plain in sham fights, unconscious of what demoralised stuff their troops were composed! Demoralisation is confined to no army, no race. Witness Hohenlinden, and the great Archduke, chief worthy to be ranked with Wellington and Napoleon, despairingly seeking a truce at any terms, because unable to check the flight of the once victorious battalions to whose command he had been brought back too late! Witness Jena and the sons of Frederick's unconquerable warriors laying down their arms by hundreds at the shout of the pursuing cuirassiers! Witness the sad story Napier has given us for our warning of which British soldiers did on their sullen retreat from Burgos! Witness, again, Bull's Run, where men who afterwards followed Grant and Sherman to unhoped for triumph over an enemy deemed invincible, behaved like some street mob stricken with panic terror. But it is impossible that demoralisation should exist so largely as to come before battle, before defeat, almost before retreat, as it did in the Imperialist Army of 1870, if the Officers had been accustomed to rough it honestly side by side by their men in peace manœuvres. For had these been regularly tested, the disease must have come to light, though no one can now surely say whether there was power under the Second Empire to remedy so dire a malady.

This subject bids me speak of another limit imposed naturally upon

all those who conduct peace operations. We hear of proposals for long-continued contests to be thoroughly fought out, and decisive victories to be won, even to the destruction, acted of course, of one force engaged. These are, and will be, but dreams. Such triumphs as are obtained by pressing a beaten army hotly from day to day are not desirable, even were they possible, in peace manœuvres. There could be none such, whilst human nature is what it is, without bitter rankling of mind, sharp accusation of those in authority, and an unhappy legacy of fancied shame on the part of those who were to enact on a smaller scale the share of Mack's, or Macmahon's, or Bourbaki's forces in their calamities. Indeed any one who attempted such operations would be left on the horns of an inevitable dilemma. Either the troops intended to be thoroughly beaten would get out of hand in their eagerness to rescue themselves from what would appear to them discredit, or, if forced along before the mock pursuer by the power of high discipline, they would be tempted to imitate the practices of a retreating army, and demoralisation is so very ugly a thing that, like certain vices, it would prove unsafe even to act it. This reason alone is sufficient to account for the universal prevalence of the wise rule, that in peace manœuvres *there must be a fresh programme, or general idea laid out from day to day.*

How is this rule to be best carried out? for that is our next inquiry. It is obvious that to attack and defend the same positions, or make the same marches over and over again, can be but little instructive. For this plain reason it is usual, when the forces are come into collision, to terminate each day's operations with an enforced retreat of one body to a fresh position, where the engagement is probably to be renewed. It is of course quite possible that the attacking force may of itself accomplish this by the success of its movements that day, when the defenders would naturally retire on the selected position beyond. But suppose the attack fails, it is still necessary, for reasons already enlarged on, to carry out the general programme, and this may reasonably and properly be done by inserting at this point a theoretical cause—from something supposed to occur outside the actual field of operations—why the defending force, though receiving proper credit for a temporary success, should fall back.

As peace campaigns cannot be carried out with the main bulk of the forces of any army, it will be but consistent with common sense to treat them in all cases as either outside of or subordinate to larger operations understood to be going on in other parts of the country, the results of which would, of course, affect them. It is by bearing this leading condition in mind from first to last, and in no other way, that the manœuvres of a few divisions can be made on any plan to accord with any conceivable contingencies in which such moderate forces would play a serious part.

It is not here, however, to be forgotten that there is another way in which a programme may be carried out of itself with less apparent dictation than under this system of constant control. This is the simple expedient of making the defending force so seriously inferior to the attacking, that it is certain the latter can outflank it and drive it

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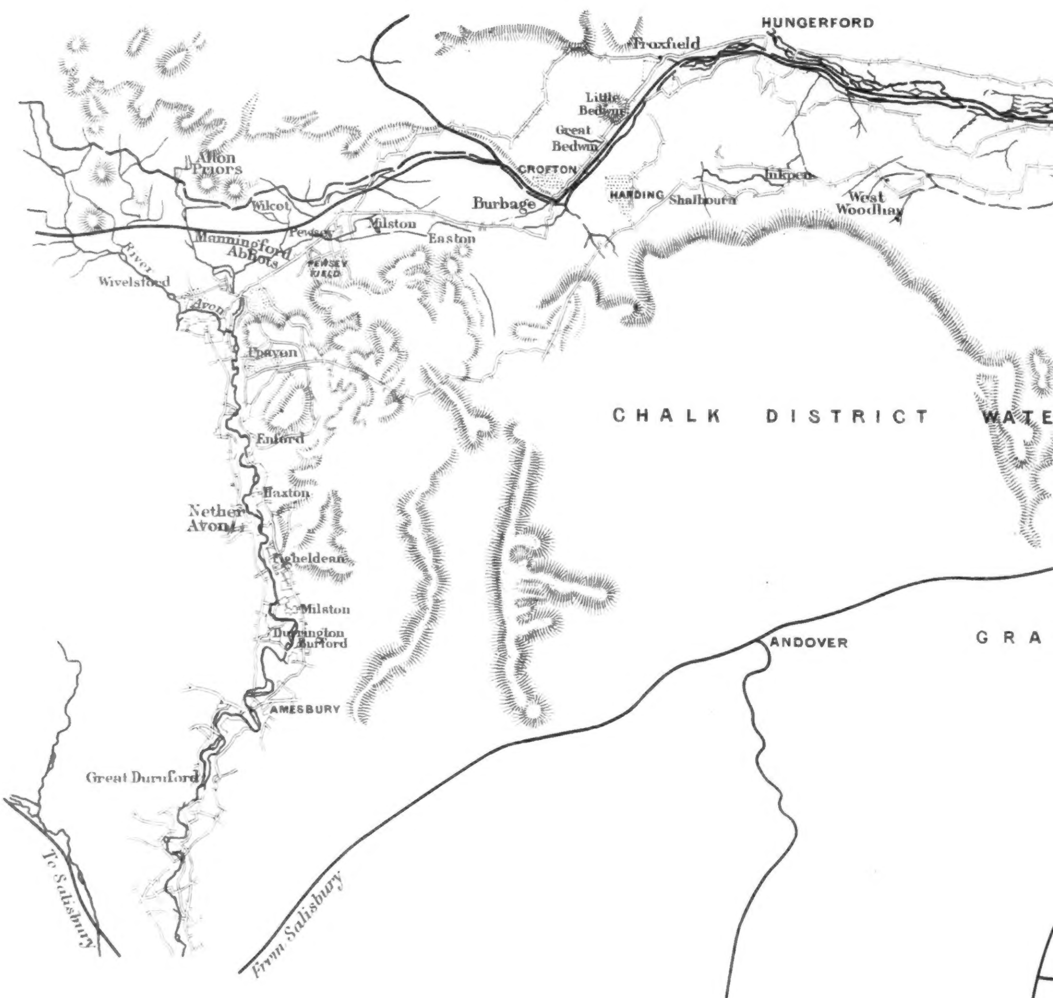
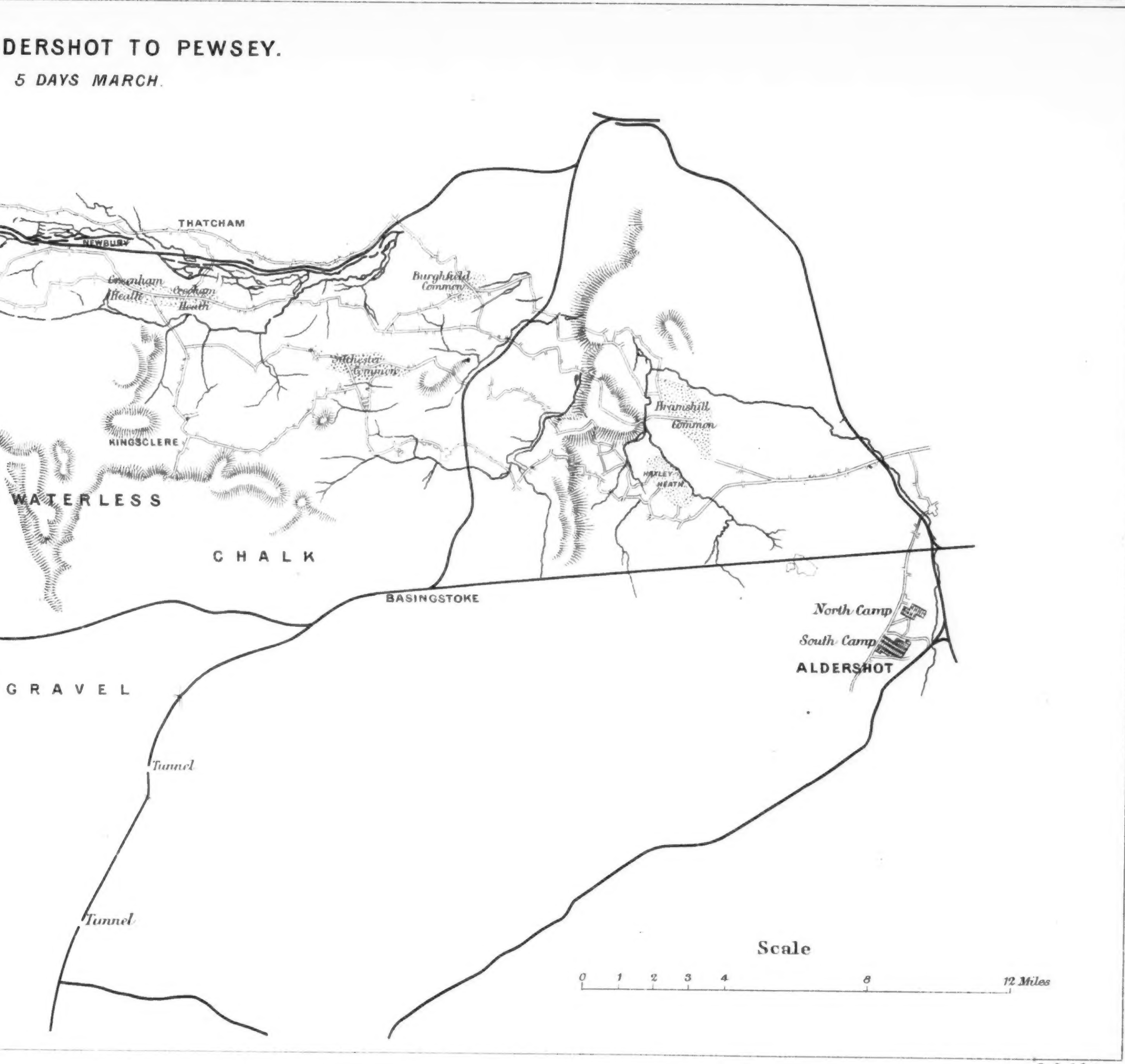
FROM ALDERSH

5 DAYS

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5 DAYS MARCH.
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Silchester Common
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Bramshill Common
HAZLEY HEATH
WATERLESS
CHALK
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South Camp
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0 1 2 3 4 8 12 Miles

J. Jobbins

back from point to point as the chief operator designs. This was the plan adopted last year by the Italians. But it is quite a mistake to suppose that it makes the whole affair more real than the struggle between two equal forces, of which one is bound to retire by order, for every tyro of military science knows that a continued retreat before a very superior force, if the men and leaders be fairly matched, is so dangerous and expensive an operation that the lesser must rapidly diminish, and if not soon reinforced—such at least is the general rule—will infallibly be destroyed within a given time. Now it has been shown why no peace army intends to practice anything approaching such destruction. The supposed reality of this method of unequal division has, therefore, no sound basis to rest on, and it can certainly claim no inherent superiority over the other, the retreat by order "for "a strategic purpose," MacClellan's historic words being here put to their strict and proper use.

Viewed in this light the operations, so far as known this year, have in them nothing of the extraordinarily improbable. That an enemy attacking this kingdom seriously should lodge a small corps in Dorsetshire expressly to divert our attention from the main invasion; that a reserve of regulars, maintained at Aldershot in case of such need, should be moved to Salisbury Plain to check it; that the former should halt at Blandford Racecourse—where he strikes on the open country—to collect his long columns straggling through the rich and closely cultivated vale behind him; that the defenders should pause when they reach the Plain, before quitting the railroad near Marlborough, to receive their reinforcements of auxiliary troops hurried down from the north; that they should then move across to await their foes advancing from Blandford in fighting order in the strongest position that he can find; that both armies should avoid the city of Salisbury—the defender, in hopes to spare its close streets and unrivalled cathedral from the dangers of shot and shell, and the invader, because he has heard of certain strong earthworks thrown up hastily round it and manned by volunteer gunners; all these suppositions are at least possibilities. But it is quite impossible that England should be seriously invaded or seriously defended by 15,000 men. No imagination—not even that of the writer of the *Battle of Dorking*—could create a mortal struggle for our empire between these numbers. It will be both simple and best therefore to view the Salisbury campaign as a mere outlying portion of some larger and more serious operations—happily only in our case to be imagined, and therefore easily conducted to a peaceful and happy close.

And now let us pass from the abstract to the concrete; from theory, which we can manage at will in the closet, to the facts to be dealt with on the ground. Let us take but one practical example of the difficulties which beset all our efforts at mimic war, just to show what indulgence they must inevitably receive from any fair critic who studies them in detail closely.

It is proposed this year to march one force at least to the scene of the encounter. The Aldershot one being nearly ready made is naturally chosen. The distance from its quarters to Pewsey, the most acces-

sible part of the Plain, is under 60 miles in a straight line, as shown by the map. The apparently simple problem of moving it has to be worked out. Now it cannot move direct, since its march would carry it right across the northern part of the great Andover and Basingstoke plateau of chalk, a district absolutely waterless, except for a few poor expensively made wells. Every mile north of the Kennet River on the other hand would carry it into a closely cultivated country, and take it so much further out of the way. The march is practically fixed therefore at once to the valley formed by the Kennet and its tributaries. For water is still a requisite of life, as much as when poor Lever's Colonel Monsoon found to his cost (readers of *Jack Hinton* will recall the passage), that Wellington entirely objected to his excuse for leaving his division without any, "that Providence didn't make rivers "run uphill." If our troops were left without water for the night we should find, I fear, that the British Army's staff is supervised in these days by eyes as keen as those of Wellington; nor do all the press writers know as well as the great Duke what the practical difficulties of field supply are.

Water is but one of these. Your troops must each night have space to camp upon (and eight and eighty acres are the very least required for a complete force of 15,000 men), food to eat, forage for their beasts, and wood for firing. Now the map will tell at a glance how limited are the facilities as to the first. It is drawn to show all the important open spaces in the Kennet Valley likely to be of any use. They have been carefully looked at, and it is found that every one will have to be used in the necessary five days' march, with one single exception only. Nor in this careful preparation, and those made for the supplies at these halting grounds, nor in the march performed without opposition—yet probably, for all that, with such precautions as any good Officer would insist on from the first for practice, though he would know perfectly well his foe was still in Dorsetshire—is there anything really inconsistent with what would have to be done if the occasion arose to meet a real enemy. All the preparations now made would then be made equally, only more hurriedly, more roughly, and of course more expensively than there is any necessity when the want is foretold and foreseen exactly.

Thus far it has been my chief, and not always pleasant, task to point out what peace manœuvres *cannot* do for us. It was needful to do this plainly; for the public has been somewhat over-sanguine, and the military world over-ambitious of results which cannot be realised. It is well now, on the other hand, to indicate certain problems which they may help in solving, besides reminding you of their proved moral value to the Army, lest we be discouraged in our pursuit of knowledge by this patriotic means. For patriotism on the part of many persons is implied wherever peace manœuvres are effectively carried out. There must be some sacrifice of individual wish on the part of those outside the Army in order to effect the object. As for those in it, it is enough here to say on their behalf, that because our aim is modest it need not the less be thorough.

IN ORGANISATION, then, first. Such manœuvres regularly carried on

should at once enable us to discover whether we can expect any military perfection from an army which has its staff separate altogether from the regiments that come under it until they meet on service, as with ourselves, and the French, and the Swiss; or whether the Germans are right in saying that a divisional and brigade staff attached permanently to the troops is an absolutely necessary element of military efficiency.

We may study, too, whether it is better for our Army to adopt the Army Corps system of some other countries, or whether an equally complete and effective military system in a moderate army cannot be obtained by forming and keeping a combined division in such districts, the Divisional General having all the necessary powers, as the Corps Commander elsewhere. It is an absolute delusion to suppose that decentralisation has any necessary connection with army corps. It has been worked out by army corps hitherto, but this simply because the problem of decentralising by divisions—to be united arbitrarily into Army commands for war purposes, just as the Germans now find they must their numerous corps—has not yet been fairly tried.

The great supply question, with its important disputed points—notably as to whether the General's Chief Supply Officer—Controller, as he is now termed—is to deal direct with him, or with a head of staff—is essentially one to be tested in peace manœuvres. So, it may be added, is that of whether the Supply Department, as existing, is thoroughly qualified (if not, it clearly should become so) to feed a force locally where local means are fairly purchasable.

IN TACTICS. Not merely does this practice give better opportunities of working combined divisions, our present fighting form, than any single camp could, but there are certain unsettled problems here, too, which may be ventured on without testing the solution with bullet or shell. Such are, what is the best size for an infantry brigade? Can we dispense with the Regimental Commander, or Sub-Brigadier of the Continent? How far can artillery be worked under the General of Division's own direction?—a problem, the answer to which in Germany just now, is very different from that which is popular with our own artillerists, who are seeking the complete independence the Germans want to get rid of, in order to be an integral part of the division. Again, would it be better to keep field artillery always field, and garrison gunners always with heavy guns?—another problem which is likely to be differently answered in Germany than it is here the fashion to reply to it. Are our engineer companies, composed, as they are, solely of trained artificers, who have at some time had an elaborate schooling in siege works, properly fitted for the more rough and sudden duties of field engineering? I have purposely not referred to the outpost duty, reconnoitring, camping, marching, and cooking, which must be practised, because everybody is agreed in admitting their advantages.

Lastly, in a NATIONAL point of view these manœuvres must be of the highest value, were it only that it is by their means chiefly we have to settle those most important problems of all—what training do our auxiliary forces require? *And what is the particular help we must look*

for from them in case of war? These great subjects I pretend to do no more here than to point to. We shall, at any rate, in peace manœuvres learn to study thoroughly the national uses of our open spaces, and find out where they lie, so as not to be forced, as in Switzerland, to manœuvre over and over again in the same district. The sad and somewhat discreditable ignorance of the soldier which exists in many of our rural districts—there are persons lately heard of, living within *two* days' ride of Aldershot who seem to regard him as an untameable and dangerous wild beast—will vanish as we use this simple means of advertising the Army, the excellence of whose regimental Officers the keenest critic of last year's manœuvres, the able *Macmillan* writer, expressed his surprise at. And I am very hopeful, from the reception the movement has hitherto encountered, and the public spirit manifested towards it by so many persons, that proprietors will each year put fewer and fewer difficulties in the way of the Army's best training, and learn to look on it not as a nuisance dangerous to property and game, but as a wholesome and salutary national exercise. And to those of my more quiet-loving countrymen who still object, I would say,—it is not we Englishmen who are the cause of our own arming. It is not we who have turned Europe into a standing camp, and made of peace no better than an armed truce. Our hands, in an international sense at least, are pure of our brother's blood.

Foreigners, too, will come here prepared to note our deficiencies, and will, doubtless, see many shortcomings; but they will see also some compensating advantages. It was not without some feeling of national pride that I could point out at an Aldershot field day recently to a strange Officer from Germany who rode beside me, the wealthiest peer by repute in all Europe doing his Colonel's work right ardently at the head of a volunteer battalion, in the dust and glare of the Long Valley. Aye! even in the very feudal formation of our Militia, and the citizen-like gathering of Volunteers there is a great lesson to be learnt; and failing, happily, the test of war, peace manœuvres will teach it best. It is that in this money-getting and peace-loving England of ours, which continental publicists affect to despise for its pacific feeling, and Communist adventurers intrigue to upturn, there are yet left many who are not content with only increasing their stores and making larger garners to pile them in, for the use, it may be, of the stranger; but who desire to hand their possessions and their liberties down intact to their children's children, and who are ready at need to stake their lives at their country's call that this first duty of the patriot may be fulfilled.

The CHAIRMAN: Gentlemen, on rising to express to Colonel Chesney the thanks of this meeting for the interesting lecture we have just heard, I am glad to have an opportunity of endorsing some of the opinions so ably stated by him. I shall certainly not attempt on such an occasion as this to go into the details which have been so clearly and definitely brought before you on the subject of these annual (or at all events occasional) peaceful manœuvres, but I am happy to have the

opportunity thus afforded me of stating how entirely I agree with what the gallant Officer has stated as regards the difficulties connected with "peace manœuvres." In fact, in some respects—singularly to say—"peace manœuvres" are far more difficult to carry out than the operations of real war, and for this simple reason, that in the one case you have a definite object, and any means may be taken to effect that definite object; in the other you can do nothing but take such means as are afforded you without trespassing on the rights of proprietors. In a luxurious and highly cultivated country like England, in order to make these manœuvres at all possible, we must be extremely cautious how they are conducted, for it is only by conducting them in a manner acceptable and agreeable to the country itself, that they can be at all maintained; and if we attempted to carry on these manœuvres as they would be carried on in real warfare, the result would be that you would see no more of them. The next thing to be considered is the question of "facility of movement," and I am very glad to have the opportunity of making a remark on that subject, as it was constantly thrown in my teeth last year that the Officers were so terribly confined by the plans of operation that they could neither show their own ability nor the endurance of the troops under their command. All I can say is, that if I were to say to Commanders of two corps of 10,000 or 15,000 men "You may act just as you like, the one against the other," and I did not restrict them at all, the chances are, that both forces would be starved within 48 hours, and everybody would be crying out "What are the authorities about to allow such things to happen, so that horses and men are positively without food in consequence of the want of management at the head of affairs?" The fact is, we have to carry everything with us. We may be within a few yards of a large wood, but we dare not cut a twig, if we did, we should be immediately indicted for trespass. However simple these matters may seem, it is not everybody who can appreciate them. And now with regard to "food;" in war the cattle are driven along with the army, and when you come to your bivouac you kill your oxen and eat them, but what were we obliged to do last year? Every single particle of meat which the troops required had to be brought down from London, because the act which exists with regard to the "cattle disease" does not allow us to drive cattle along the roads. Then as regards the "supply of water;" the map before you shows you what difficulties there are about water on the line of country between Aldershot and Salisbury Plain. Now, of course, we cannot go away from our water supply. It may be that on our right and left we have fine tracts of open country, and people say "Why do not the troops go over those fine tracts of country?" But you cannot do it, and why? Because you get away from your water supply, and both men and horses would suffer. These are reasons which oblige me, if I am in command, instead of saying "I will have my camp *here* and *there*, because we will finish the manœuvre there," to say "No, the troops must retire and march to such and such places," because those are plots of ground which have been examined, and are found to have a good water supply, and because, in addition to that, all the supplies have been brought to those points. I have

great pleasure in entirely endorsing what has been so ably and so judiciously put forward by Colonel Chesney, and I trust that I may be permitted, on the part of this meeting, to express our sense of the very able lecture that he has given.

Evening Meeting.

Wednesday, May 15th, 1872.

General Sir WILLIAM J. CODRINGTON, G.C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 8th and 15th May, 1872.

LIFE.

Maclear, John, F.L.P., Comr. R.N.

ANNUAL.

Radcliffe, Henry, Capt. South Middx. Rifle Vols.
Paterson, H.W., Capt. h.-p. 4th W. I. Regt.
Gunning, C. G., Capt. Madras Staff Corps.

OUR NAVAL AND MILITARY ESTABLISHMENTS REGARDED WITH REFERENCE TO THE DANGERS OF INVASION.

By W. Vernon Harcourt, Esq., Q.C., M.P.

The Chairman: Gentlemen, allow me to introduce to you Mr. Vernon Harcourt, who is to lecture on a subject that is interesting to all members of the Military profession; but Mr. Harcourt knows that we are not a political assembly, and that the subjects that are mooted here are those which relate to the defence of England, and to the various subjects connected with the naval and the military services of the country.

Mr. Vernon Harcourt: This is the second time that I have had the honour of standing in this place. The first time by the invitation of the Council of this Institution, when I was asked to make some remarks on a question which is not yet concluded, but which is of great interest, viz., the question of the "Alabama Claims." That had to do with a matter of international law about which I might be supposed to know something. To-night I have been invited by the Council of the Institution to make some remarks upon a subject about which I may be fairly assumed to know nothing, viz., "naval and military affairs," so that when I received the letter from your Secretary asking me to give a lecture here, I must confess that I looked at the date with some surprise, and wondered whether it was dated on the 1st April. I was rather disposed to write back an answer and say, in the terms of the old proverb,

that the cobbler ought to confine himself to his last. But, upon further reflection, it did occur to me that, after all, the questions discussed in this Institution are questions which affect not military or naval men alone, but the interests of every class of the community; and that if it were possible to introduce even more than exists at present, a system of intercommunication of ideas between the civilian and the professional elements in the country, it would be of great advantage to all persons concerned—as well to the naval and military professions as to the public at large. Therefore, when I accepted the Council's invitation I accepted it in this sense: I thought, though I could not come here to teach, that I and many others who feel like me, might come here and learn a great deal by propounding to the scientific members of the military profession, of whom this Institution is mainly composed—and one of its main objects is, I suppose, to lead to the interchange of ideas amongst them—to propound to them certain questions about which we know nothing and about which they know a great deal, but which seriously affect the interests of the nation at large. Therefore, when I accepted the invitation, it was strictly in my professional capacity, because the business of a lawyer is not so much to know anything himself as to endeavour to extract information from others, sometimes by examination-in-chief of friendly witnesses, sometimes by cross-examination of those who may be considered adverse. And thus, though a lawyer never knows anything himself, he is sometimes like the man in Shakspeare, who was said to be the cause of laughter in others; he may sometimes be the means of extracting information from other people. I have to apologise to the members of this Institution that, in consequence of the press of business, I have not been able to write what I have got to say; I must therefore ask them to make allowance for the imperfect manner in which I may make the observations which I have to offer. I hope they will accept whatever I shall say, in whatever form it is conveyed, not as didactic, but as interrogatory altogether. When speaking in the presence of persons of the greatest information, the remarks that I shall make, will be for the purpose of asking them to communicate to one another, and, through this Institution to the public, information upon matters in which the public is largely interested.

Now the question of the armaments of this country is, of course, in every point of view the most important question probably that the public has to consider. In the first place, upon the armaments of the country depend the honour and the safety of the empire. That is the first consideration. The second consideration is the question of economy in expenditure, which I put necessarily second to the first. With reference to that matter, allow me to say here that I think a great deal of misunderstanding has arisen upon this question. I know there have been persons, and I regret it more than anybody, who have used language with reference to the two great professions, —which, after all, are the pillars upon which the greatness of the English empire has been reared, and upon which it must always rest, —in a tone which I think everybody must condemn. The suggestion that there is any desire on the part of these professions to keep up

armaments at a higher rate than is necessary, I believe to be entirely unfounded. On the other hand, that there should be any class of people who desire to see those armaments reduced below that point which is essential for the safety and the honour of the empire, I believe to be equally unfounded; therefore, the real question is, what is the nature and the extent of those armaments which are necessary and desirable for both those purposes? That is a question upon which I am here to-night to elicit information, if I can, from the scientific members of both professions. That every class of the community in this country will cheerfully bear the burdens which are necessary for the purpose of maintaining the armaments requisite for the maintenance of the honour and safety of this country, is a thing we cannot allow ourselves to doubt. For my part, all I can say is, as a member of another profession, my belief is that, in respect to the magnitude and laboriousness of the services they render, I believe there are no professions so inadequately remunerated as those of the Army and the Navy; but, as the Chairman has already pointed out, the subject before us is one into which no political considerations can enter, therefore I put that out of question altogether. Matters of public policy with reference to what may be considered the foreign policy of this empire, how far the Army and Navy may be required to exercise influence in European questions, that, no doubt, is a very interesting question, but one which would not be fitted to discuss here, and I put that out of the question altogether to-night. I do not ask what is the army or navy which would be necessary for England to carry on campaigns abroad, and to exercise influence in European affairs. Probably most people will agree that it is difficult, perhaps impossible, to maintain in this country an army which could cope with the armaments of the great military monarchies upon the continent of Europe. However, that also is a question which I do not raise here for a moment.

The question, then, to which I would ask your attention is that of the defence of the empire, and to that question alone. There is a question which necessarily occupies, and has very much agitated public attention—that is the question of the invasion of this country, in which I also include its colonies and its other dependencies. In many foreign countries, without doubt, matters affecting military and naval affairs are determined without any reference to public opinion, by a determination of the Governments which control the destinies of those countries; but in this country, our armaments and the defence of the empire must depend upon the conviction of the public opinion; and whereas public opinion can be rightly led or misled according to the information it receives, so it seems to me that an Institution of this character may be of the highest value in rightly informing public opinion upon questions of that nature.

Now there is one fact—and it is only facts that I wish to give, because opinions coming from me would be of no value—there is one fact to which I would venture to call your attention. There is no question that at this moment in this country we are maintaining a military land force as nearly as possible double that which previously to the Crimean war, and even during the period of the great European war, in the heat and

fear of an invasion by the First Napoleon, we ever maintained. In round numbers we may say that the land forces of this country used to be 50,000, and in round numbers you may equally say that at this time they are 100,000 men. Now that is a fact which has to be explained; of course there is some reason for that fact or it would not exist. That requires to be explained, for I am sure the moment it is satisfactorily explained, no jealousy, no dislike of the burdens which must necessarily be imposed, would exist for a moment in this country. One of the first questions that I have to ask, and which I venture to think the ignorant public have a right to ask of the scientific members of the military profession, is why it has become necessary in the modern condition of things in Europe that the land forces maintained in this country should be double in number that which they were, say 20 years ago. If I might be allowed to suggest, it cannot depend upon the increased military forces of the continent, because the military forces of the continent have at all times, long before that period, been immensely greater than those of this country. There was no period at the beginning of this century, or at any time down to the year 1850, which is the period before the Crimean war, when the military monarchies of Europe had not three or four times as many troops as this country had. If you take Austria, France, Russia, or Prussia, at all those times they had a much larger number of men than ever we had.

Now, I suppose if you have got 50,000 men in this country, and another country has got 300,000, it signifies very little whether the other country has got 300,000 or whether it has got 1,000,000 of men, because the superiority of those forces is already so great that if it merely depended upon the number of the land forces, the doubling of a force which was already six times your own, really makes no difference. Therefore, the change cannot depend upon any mere increase of the land forces of continental powers. We must always have been at the mercy of the continent if it was necessary for us to maintain a land force equivalent to that of the military powers of the continent, because we never at any time had anything at all to compare with theirs. I think that at the time of the threatened invasion in 1805, just before Austerlitz, the regular land forces of England were 60,000 men, at the time when Napoleon had 300,000 or 400,000 men, with which he fought the great campaigns of Austerlitz and Vienna. Then it must depend upon something else. It depends upon this question surely, viz., how many men can be brought here; it does not depend upon how many men there are on the continent, because it signifies extremely little, if you have got a very narrow conduit pipe, whether you have got the Atlantic Ocean at the end of it, or whether you have got a washing tub, so it depends upon the strength of the tap and the smallness of the pipe, as to the number of people that may be poured into your shores, not upon the magnitude of the reservoir at the other end. Therefore, the question is how many men can be brought here; and the real question with reference to invasion is, I would venture to suggest—and here again I do it interrogatively altogether—has the power of bringing men to England increased in the last 20 years relatively to the power of resisting their power of coming

here, or has it diminished? I venture to submit that that is the real question to be argued. It is immaterial whether there may be 1,000,000, or 10,000,000, or 100,000,000 of men ready to come from the continent, unless the means of transporting them to these shores has been increased in the meanwhile. Twenty or thirty years ago there is no doubt, there was always on the continent of Europe a far greater force that might have been brought, if it could have been brought, than there ever was in England to meet them. Therefore, the real question we have to discuss is, has the transporting power been increased by anything that has since happened, because unless the transporting power, or, as I venture to put it, the conduit pipe, which is to introduce the hostile element, has been enlarged, then the danger of the influx has not been increased?

There have been many popular publications which have agitated the public mind which seem to me to have altogether passed by this consideration, and have declined to discuss it. There is the well-known publication called "The Battle of Dorking." "The Battle of Dorking" assumes the passage. Well, that is begging the whole question, because if the passage is easy, and there is nothing to be done in passing the Channel, everybody knows that the military power of England is, and always has been, infinitely inferior to that of the great military monarchies. Therefore, if you choose to place England, by the assumptions of "The Battle of Dorking," as a continental power, with its confines approaching those of the great military powers, England has always been entirely defenceless. But I venture to think that that is not a way of treating the subject that will be satisfactory either to scientific members of the profession, or to the ordinary uninstructed public mind. The question is, what is the power which exists on the part of the great military monarchies of Europe of bringing their military power to bear upon the shores of this country? That is the question upon which, I would venture to suggest to this Institution the public mind would like to be enlightened. Before we begin to discuss what the North German army—for instance*—is going to do when it gets here, I would ask this Institution to tell us how it is to get here, because that seems to me to be the subject which has first to be settled.

As a person who has had to do with examinations, I know it is much easier to set questions than to answer them. I am going, with the leave of this Institution, to set a question which I should like to have answered. I will suppose a particular force to be available in this country. For the purpose of the problem, I will suppose that there is available in this country, capable, by railways and other resources we have, of being concentrated within a brief period upon a particular point, I will say 30,000 infantry of the line, behind that force a certain number of reserves, militia and volunteers, which you may put at any figure you like—you may put it at 30,000 or 50,000, or whatever figure you like. Then I will put in addition to that, what we may consider to exist in this country at this time, an available force of

* The Prussian or North German army is mentioned throughout the argument only by way of illustration.—Ed.

10,000 cavalry. I believe the actual force of cavalry in this country is between 13,000 and 14,000 men, and about 8,000 horses, but this may be incorrect, therefore I think it would be fair to put the force of cavalry at 10,000 men. Then there would be 5,000 engineers, and what we have in this country at this moment are 56 batteries of field artillery—I would put it at 50 batteries of field artillery. That is what I assume to be the force with which you have to deal. You will remark that I have put the infantry of the line at one-half the actual existing force. I put it at 30,000 infantry of the line, 10,000 cavalry, 5,000 engineers, 50 batteries of field artillery. You might have 100 batteries of field artillery, because the number of artillerymen in this country is about 18,000. There are 15,000 foot artillery and 3,000 horse artillery, and I believe the number of men that go to a battery is 150 and 100 horses. Therefore you might, if you had the guns, easily have 100 batteries of field artillery, with the men for that number. Now I assume that as an hypothesis, and I ask what is the force which by any prudent military power would be provided to invade a country possessing such a force as that? I ask this Institution, and I venture to think the public have some right to ask the scientific members of an Institution like this for an answer to that question—what is the force which might be reasonably proposed to invade a country possessing such an army as that? Now I do not suppose that such a power would bring less infantry than 30,000 men if they knew there were 30,000 men here and irregular reserves behind them. They might pay us the compliment, as Napoleon Buonaparte did, of thinking it would not be worth while to invade England with less than 170,000 men. However, I will assume a country would not think of invading England with less than 30,000 infantry. I presume also, if we have 10,000 cavalry, they would not bring less than that; because if there is anything that we have learned from the Franco-Prussian war, it is, the great value of cavalry, especially with an invading army. Their foraging, their collecting materials of all kinds, horses, cattle, &c., must very much depend upon their having a superiority, or, at all events, an equality of cavalry, for I suppose a force of that kind would not move in the presence of a greatly superior force of cavalry which would clear the country before them, and in fact prevent their moving at all. Therefore I assume that they would not start with less than 10,000 cavalry, if we had got 10,000 cavalry here. Then as to artillery, we have 50 batteries, and I also venture to think that the enemy would not come with less field artillery than we possess at this moment, especially as I suppose we should have a very great power of establishing guns of position. I will assume that. Then the question that I have to propound to this Institution is, what is the amount of transport which is required to embark such a force as that? What vessels do you require to embark 30,000 infantry, 10,000 cavalry, 50 batteries of field artillery, and the camp followers and the non-combatants which are requisite for such a force? That is a question which I venture to think the scientific members of this Institution ought to give some answer to. It is a question capable of being solved I imagine, and it is one that we should like to have an answer to.

In an invasion—I think I am not wrong in saying—there are three matters to be considered: first of all the embarkation and the transport; secondly, the crossing; and thirdly, the disembarkation. I would like to ask an opinion upon these three points separately.

First of all as to the embarkation. What is the shipping necessary for such a force as that? You will see that what I have put, is practically an army of 50,000 men: 30,000 infantry, 10,000 cavalry, the engineers and 50 batteries of artillery, taking 150 men to a battery, would be about 10,000 more men. That is an army of 50,000 men. What is the shipping required to embark an army of 50,000 men, and where is it to come from?

In this country we are very little in the habit of appreciating the inferiority of other countries with respect to the mercantile marine. We are so in the habit of seeing in the ports of London, Liverpool, Glasgow, and Southampton, hundreds of great steamers going and coming, that we imagine that that is the condition of other nations. It is not so at all. If you examine the mercantile marine of great countries like France, Germany, Russia, you will find that they have not got any. Russia practically has got no ocean-going steamers at all. She has got a certain number of small coasting steamers of 200 or 300 tons burden. You will find that that is the case with Germany also. I find in the returns that the mercantile marine of North Germany is 48,000 men, which is about 12,000 less than the Royal Marine of this country. No doubt at Bremen, and places of that kind, they have a few large liners which go abroad; but if you come to examine the history of the mercantile marine of all nations except England, you will find it is practically insignificant.* Now I think that is a matter that is to be borne in mind. You will find in most cases where great military nations have had to undertake foreign expeditions like the French to the Crimea, they have had to put their soldiers on board their men-of-war. Why? Because they have nowhere else to put them. But a country that is going to invade a naval power cannot put its men on board men-of-war because the men-of-war will have to fight, and they will have to keep their men-of-war clear in order to fight. Therefore they must find their transport elsewhere. Then where are they going to find their transport? Happily the Neutrality Laws, which are becoming more and more understood, will prevent their hiring transport, because for a neutral Power to let transport to a Power at war, is an act of war. Therefore they can only get transport from their own resources or from their allies, because they cannot hire it from other countries. I wish again to ask the scientific members of the profession what is the number of vessels which would be required to embark this army of 50,000 men composed as I have suggested. It is to carry 30,000 infantry; that is not very difficult, because you may pack the infantry soldier in a small space; but you are going to carry 10,000 cavalry; you do not put those into a very limited number of vessels.

* I have, since this paper was read, ascertained, by the kindness of the Consul of the North German Empire, the exact figures. They are as follows:—North German Lloyds, from Bremen, 20 large steamers; Hamburg line, 17 steamers; Baltic Lloyds, 3; total, 40. There are about 15 more in course of construction.

You are going to carry 300 guns; you do not put those into a very small space, nor the horses which are to draw them. You are going to carry a certain number of non-combatants, and that is a subject upon which I would ask the opinion of the Institution. What is the number of non-combatants which will accompany such an army as that? You are going to carry stores and provisions I presume, because the rashest Power in the world would not come to England without having a fortnight's provisions with him for men and horses; and you must have your ambulance corps and so on. Then, besides that, you must have your reserves which are to follow up and to supply your army, supposing it established and landed. What do you imagine would be the number of shipping that would suffice to carry such an army as that? That, I think, is a question which ought not to be left to speculation, but is capable of a solution.

The only facts that I can arrive at myself are those derived from recent experience. I will say nothing about Napoleon's great attempt, where he had nearly 2,000 vessels, because the conditions of the times are so different, that I do not think it is applicable. Now let us look at what happened in the Crimean expedition, and what were the figures. But, first of all, there are several matters to be considered. What is the time taken in making such preparations as these? because upon time depends notice, and upon notice depends the means you have of encountering attempts of this character. On the 20th August—I take this date from Mr. Kinglake's book—was taken the determination to sail from Varna to the Crimea. On the 24th August the embarkation commenced. On September 6th the flotilla sailed. Now that gives about a fortnight for the embarkation. I do not insist upon that because at Varna there were not the opportunities you might have in a country where there are docks, and where you might embark more rapidly than that; but I do call attention to this, that in a passage of about 300 miles, which is about the distance from the nearest point in Prussia (supposing we take Wilhelmshaven as the place from which an attack from Germany might come), the passage took eight days. People writing popularly on these subjects say, "300 miles! Oh, that "is 24 hours' sail." But that is not the way in which great armaments go. You might just as well calculate that because a man might walk 30 or 40 miles a day an army could do the same. That is not so, because, according to the experience, it was about 300 miles from Varna to the old fort, and from the time the flotilla sailed, to the time the landing commenced, was eight days, in perfectly calm weather, with no opposition, and under most favourable circumstances. How many days did it take to land the troops in the Crimea? The English had about 25,000 men; they had 1,000 cavalry, and they had 60 guns. It took them five days to land the troops. That gives one some notion of what is the nature of these operations. Mr. Kinglake, in his book, prides himself upon the extraordinary rapidity and activity with which the thing was done. He says, "In five October days 25,000 "men were landed." These are practical matters of experience; from the day when the embarkation commenced at Varna to the day when the battle of Alma was fought, which was two days after the

landing was concluded, was exactly a month. Now that seems to me—unless there is some answer to it—to be a reply to the suggestion of *invasion by surprise.* And bear in mind this was an operation conducted by the three greatest maritime powers in the world, England, France, and, I believe you might say at that time, and even now, that the third great maritime power of the world was Turkey. At all events, you had a combination of those three Powers without any naval opposition whatever, who embarked an army of 60,000 men, and who embarked it so incompletely, that the French took no cavalry at all. They were not able to carry the horses for their guns: and being covered by the English Fleet, they carried their men on board their men-of-war, because they had no others. They got their transports towed by Turkish steamers. That was the condition of the maritime resources of France with reference to its power of carrying 25,000 men. England was in a different position. England had unlimited resources for transport. I would ask the attention of the Institution to the number of vessels which England employed upon that occasion. She kept her fleet for fighting and to cover the embarkation. How many vessels did it take for England to carry 25,000 men, 1,000 cavalry, and 60 guns, that is, 10 field batteries. Mr. Kinglake does not give the details of it in his book, but I find it stated in the "Annual Register" that there were* 400 transports. In Bazancourt's book, I find that the French took 25,000 infantry, 2,000 artillerymen, 800 engineers, 68 cannon. How did they carry them? They had 48 vessels of war, many of them three deckers, in which they packed their men; and they had 49 transports; that is, 97 vessels. The Turks had 7,000 infantry. They had 16 vessels of war towing 16 transports, making altogether 130 vessels. They carried no cavalry; they carried no land transport; they were not able to carry horses for their guns. Now, I do not suppose that is the way in which England is to be invaded. A military power would not come without cavalry, without land transport, and without horses for their guns. Then, where is the transport to come from? England, on the other hand, which did carry its equivalent forces, with 1,000 cavalry, had 400 transports. Now if the French Army and the Turks had been carried under similar circumstances, and if they had carried cavalry equivalent to the Army, and if they had carried horses for their guns, and if they had carried artillery, I do not think upon these figures that I have given you that it would be too much to say that, for that Army, it would have been necessary if it had to fight its way with its own fleet covering it, to have had 1,000 transports. I want to know where are 1,000 transports to be found in Europe, or in America, for that matter? Of course ships for transport may be constructed. But the construction of transports for an invasion is a matter of time; it is notice; it is a thing that people know about. But the thing we really ought to know is this—what is the amount of shipping that would be required? I have endeavoured to ascertain the number of horses to be carried in the expedition I have

* This figure is inaccurate. It will be seen that it was corrected at a later stage of the discussion.

supposed, for they are the things about which there is real difficulty. There are, first of all, 10,000 cavalry horses. Take 50 batteries of artillery, which would be equivalent to the force we had in this country. On an average you may take 100 horses to a battery of artillery. that would be 5,000 horses more. How many more horses must be added for the land transport, the ambulance, and the general service of the army? Is it too much to say for an army of 50,000 men you must have 10,000 horses, or one horse to five men? If that is so, you have got to transport 25,000 horses, because I conceive an army invading this country must have the means of moving when it gets here, because I suppose our own cavalry would clear the country within ten miles of the landing, so that the army coming here would not be able to find transport on the spot. What is the shipping which is required to carry 25,000 horses? Now the only other document which I know of bearing on the subject—I believe it was not considered altogether a very economical and judicious arrangement—relates to the Abyssinian expedition. The facts of that expedition are to be found in the Report of the Committee of the House of Commons. There were 14,000 combatants sent to Abyssinia. The non-combatants who attended them were 50,000. I do not suppose that precedent would be pursued under the German organization. But that was the process in our campaign in Abyssinia. In order to attend upon the 14,000 combatants there were 50,000 non-combatants carried to Abyssinia. What were the number of beasts of burden of various kinds, horses, mules, donkeys, camels required, in order to put 15,000 combatants in marching order in Abyssinia? There were 35,000, exclusive of four elephants, that is to say, three beasts of burden to every man. For an army of 50,000 men, if that were so, it would be 150,000 horses. But I do not assume that. I put it at a very low figure. I assume that the German Army might be content with 25,000 horses as against the 35,000 animals that we employed in Abyssinia for 15,000 men. What was the amount of transport we employed there? There were 302,000 tons of transport employed in carrying the expedition. If you examine the list of transports you will find page after page of the Parliamentary Report filled with lists of vessels of 1,000, 2,000, and even 3,000 tons, amounting to several hundreds in number, that were employed for the purpose of putting that army ashore. It requires very little knowledge of the history of the world to know that no country could have done it except England. It is not to be done anywhere else; the vessels do not exist. Therefore, I want upon this first branch of the question, a scientific answer from this Institution as to what number of steam-ships (of a thousand tons burthen we will say), it would require to carry such an army as I have described, with its cavalry, its guns, its stores, and its camp followers? That, I think, is a question we may fairly submit to your consideration, and require an answer to it.

Now, I come to the second stage of the question. Assuming that you have got that amonnt of transport, that you have got it in a safe harbour where you can embark with ease, that you have got your troops on board, how are you going to get across? That depends of course upon

your own naval force and the naval force that you have to oppose, and upon that subject I would again venture to ask the opinion of this Institution what the first process would be; because these things are not done in a corner. You do not collect a flotilla of transports in a harbour in Europe without somebody suspecting that something is going to be done; you do not put an army of 50,000 men, with 10,000 cavalry and 300 guns, on board, just in the same way that you go down by the night train and cross from Dover, though I know that is the popular idea. These are things which take some time, which attract some attention, and you have an idea that something is about to occur. I imagine, then, that if you have got a fleet at all you would blockade the harbour where these transports are collected, and would watch what is going to occur when they come out. In old times a blockade with sailing vessels was carried on at a distance. Nelson blockaded Toulon from Sardinia; and in such circumstances it was possible for a fleet to sail out and nobody to know anything about it. But we know since the American civil war, that you may maintain an absolute blockade not only in summer but in winter, as the blockade of Charleston, Wilmington, and other places was maintained by steam, in a manner in which a blockade was never maintained before. Nay, more than that. I venture to think that with the present appliances of swift vessels and telegraphs, you might know in a very short time what was happening in the North Sea at any moment. I do not see why you could not have the "Great Eastern" anchored off the harbour in constant communication with the War Office in London, with the present means of ocean telegraphy which we possess. At all events, you might have rapid communication; and if you have a superior fleet and an effective blockade, a flotilla of that character could not leave the harbour unless it had a fleet prepared to fight a general action and beat the blockading squadron, otherwise it would not signify whether they had got a million of men or ten millions of men on board; unless they could command the sea by beating the fleet outside they would not have a chance of success. I was looking the other day at a paper, which has recently attracted the attention of this Institution, by Captain Tulloch, and I saw a sentiment, which coincides with my own, in a paper that he read on "the defence of London." He said in answer to Captain Hoseason, "To answer your question first, I may say that I "start with the assumption that the enemy would have the command "of the sea, because to suppose that he would attempt an invasion as "long as the English Fleet was on the water is out of the question." I venture to think that that has been the assumption of every military man from time out of mind. It certainly was the assumption of Napoleon; it has been the assumption of every man who has dealt with this question hitherto. Therefore the question is, what probability or possibility is there that any European Power, or any combination of European Powers, can command the sea, either temporarily or permanently, in the existing state of the establishments of this country?

Now this is the only point upon which I can hope to supply any information to the Institution which may be considered of any value; viz., the actually existing state of the English Navy and that of the

navies of Europe. In the year 1870 the ships completed and building —I am speaking now of ironclads alone, which for fighting purposes are really the only ones worth considering—were forty-seven vessels. Of these the "Captain" was lost, and the "Prince Consort" is a vessel just condemned, leaving forty-five. There have been built and completed since, four. There is one which has just been commenced since; however, I do not count that, because that is not completed. That leaves forty-nine completed ironclads in England which are more or less effective. The country against which we have always been building, and with which we are apt to compare, is France. In 1870 it was estimated that the French had fifty-two ironclads, but of these eight have, since that time, been condemned as worthless. That leaves forty-four; but of these fifty-two, ten, which were commenced, have not been completed and are in a very imperfect condition of completion. Now that leaves, as against the English forty-nine iron-clads, thirty-four French ironclads.

English Navy at commencement of year 1870.

Ships completed and building	47
Lost ("Captain")	1
Condemned ("Prince Consort")	1
	45
Built and completed since—	
"Hecate" "Gorgon" "Hydra" "Cyclops"	4
Commenced since ("Fury")	1
	50
All completed save "Fury"	1
Total completed, May, 1872	49

French Navy at commencement of 1870.

Ships completed and building	51
Commenced since 1870 ("Triomphante")	1
	52
Of these, *condemned*—	

3 Ironclads	"Gloire", "Normandie", "Invincible"	
4 Ironclad floating batteries.	"Paixhans", "Palestre", "Peiho", "Saigon"	8
1 Ram	"Rochambeau"	
		44

Of these, *not completed*—

		Amount done.	
5 1st class Ironclads	"Colbert"	$\frac{4}{100}$	
	"Trident"	$\frac{10}{100}$	
	"Friedland"	$\frac{72}{100}$	
	"Suffren"	$\frac{60}{100}$	
	"Richelieu"	$\frac{30}{100}$	
3 Ironclad corvettes	"La Galissonière"		10
	"Victorieuse"	$\frac{10}{100}$	
	"Triomphante"	$\frac{14}{100}$	
2 Rams	"Belier"	$\frac{84}{100}$	
	"Tigre"	$\frac{68}{100}$	
Total completed, May, 1872			34

Now, I have got here before me a paper drawn up upon very authentic information. Of course this is a subject of which I know nothing myself, but I can give it upon authority, upon which I can entirely rely; it is an attempt to pair off the French Navy against equivalent ships in the English Navy. See what you have left after you have done that. It is a difficult thing, of course, to make this comparison, because there are three elements to be considered. There is first, the thickness of armour-plating when you are comparing equivalent vessels; then there is the weight of the guns; and then there is the speed of the vessels. Of course the comparison must vary according to these elements. But I would make this observation; it is known that there are a certain number of vessels which are considered obsolete in England; but then it must be considered that there are an equal number of vessels which are considered obsolete in France. We must pair off the obsolete vessels of one country against the obsolete vessels of the other. When you are dealing with the weight of guns, if you have got $6\frac{1}{2}$-ton guns which will penetrate the armour of another vessel, it signifies very little that that vessel should have heavier guns, because if the guns of each vessel will penetrate the armour of the other, the advantage, I am told, remains with the number of guns. Just as it would be with wooden vessels, if you had guns that equally penetrated, then the superiority would remain with the vessel which had the greater number of guns. To gentlemen who know a greatdeal more about it than I do, I would just read this list, and the pairing which is suggested as between the English and French vessels.

SHIPS.

	English.	No. of each class.
Ironclads (completed) sea-going.	"Hercules" "Sultan"	2
	"Bellerophon" "Lord Warden" "Lord Clyde" "Agincourt" "Minotaur" "Northumberland" "Repulse" "Royal Alfred" "Penelope"	9
	"Achilles"	1
	"Caledonia" "Royal Oak"	2
	"Resistance"	1
	"Ocean" "Zealous" "Hector" "Valiant" "Defence" "Pallas" "Favourite"	7
Rams and Turret-ships.	"Hotspur" "Rupert"	2
	"Viper" "Vixen" "Waterwitch" "Enterprise" "Research"	5
	"Royal Sovereign" "Prince Albert"	2
		31
Ships remaining over.	"Monarch" "Devastation" "Thunderer"	3
	"Audacious" "Invincible" "Iron Duke" "Vanguard" "Swiftsure" "Triumph"	6
	"Warrior" "Black Prince"	2
	"Hecate" "Gorgon" "Hydra" "Cyclops"	4
	"Glatton" "Scorpion" "Wyvern"	3
Grand Total		49

	French.	No. of each class.
	"Ocean" "Marengo"	2
	"Flandres" "Gauloise" "Guyenne" "Heroine" "Magnanime" "Provence" "Revanche" "Savoie" "Surveillante" "Valeureuse"	10
	"Belliqueuse"	1
	"Magenta" "Solferino"	2
	"Couronne"	1
	"Alma" "Armide" "Atalante" "Montcalm" "Jeanne d'Arc" "Thétis" "Reine Blanche"	7
	"Taureau" "Cerbère" "Boule Dogue"	3
	"Onondaga"	1
Seven floating batteries.	"Embuscade" "Imprenable" "Protectrice" "Refuge" "Opiniâtre" "Arrogante" "Implacable"	7
		34

Of course I give this upon no authority of my own, but upon authority upon which I can rely. I am told that those thirty-one English ironclads, regarding the elements to which I have referred, may be fairly compared with the thirty-four French vessels that I have named.

Now, what remains after that? You have paired off against the great naval Power of the world, and you have remaining nineteen English ironclads of the first class, after you have disposed of the French Navy by an equal force.

Now, what is the condition of the other navies of Europe?

First of all, let us take Prussia, as a country from which invasion is considered formidable. Prussia has three ironclads, none of which she has been able to build herself. Two have been built in England, and one in France. I believe she is now attempting to build an ironclad. That is the country by which a nation with forty-nine ironclads is about to be invaded! What I want to ask this Institution is, why is it more probable that a country, removed by 300 miles of sea, with fifty ironclads, is going to be invaded by a country with three ironclads, than that England with 5,000 men is going to march to Berlin over the Prussian army? I cannot understand why the same process of reasoning that is applied to a military force is not to be applied to a naval force. If you have an army of 5,000 men to attack an army of 500,000 men, you hardly think the matter worth discussing. Then is it worth discussing the invasion of a country which has fifty ironclads by a country which has three ironclads? That is a question I venture to put to a scientific Institution. It is a question that may be susceptible of a scientific answer; but to an ordinary mind it appears to be as great a delusion as it would be to march to Berlin with an English Militia regiment, which at present we do not consider to be an easy performance.

There is another country which might be combined with Prussia, which it is also worth considering, and that is Russia.

What is the condition of the Navy of Russia? Russia has two ironclads, of which the plating is 4½-inch armour, and which are described as being of the same style as the "Warrior," but inferior. The "Warrior" is considered to be one of our most inferior ironclads at this moment; and the best of the ironclads of Russia are inferior to the "Warrior" with her 4½-inch armour. Then there are three ironclads which are described as of the same style as the "Defence," but inferior to that. That is the naval force of Russia. Now, if you put Russia and Prussia together, you will find that they have seven ironclads. The Prussian ironclads, I believe, are very good ones, and the Russian extremely bad ones. They have a number of monitors besides, which are meant for coast defence. They are building also, I ought to mention, two large vessels of the "Devastation" class. If you put Russia and Prussia together, they have what you may call seven moderate ironclads among them, as against nineteen ironclads of England of the first class, after disposing of the French Navy.

Then, if you like to add to these two countries the United States, which possesses no ironclad that is capable with safety unaccompanied

by a consort, of crossing the Atlantic, you have a combination of Powers with which you may have to deal.

We have heard it said that we should always be prepared for all emergencies. Now, I propose that we should deal with this combination of circumstances—that we should have war made upon us at once by France, Russia, Prussia, and the United States. If you can conceive all these countries combined, you will find that after putting ship for ship against theirs, it would leave ten ironclads of the first order to spare as against them. Now, what I have to ask of this Institution as a scientific body is, to describe what is the process by which, in the presence of a fleet of that description, a flotilla of a thousand transports is going to put to sea, and how is it going to be dealt with in the presence of a fleet of that description? It is said that fleets are decoyed away. It is not easy to decoy away an ironclad; it is rather too heavy a burden to be decoyed easily. All our ironclads are at home or in the Mediterranean, with three exceptions—one in a distant part of the world, and two elsewhere. That is the existing condition of things. You say that might be altered. It may be altered. Russia and Prussia may build more vessels. They have never been able to build one yet, although I believe they are trying to do so. Where are the dockyards of Prussia—dockyards which correspond to Chatham, Portsmouth, Plymouth, Pembroke? And, after that, where are the dockyards to correspond to the great private dockyards on the Clyde and the Mersey, of Messrs. Laird and other great contractors? If Prussia began to construct, we could build ten vessels to one she could build, as soon as we knew what she was doing. Where is Russia going to construct against us? Where is the United States going to construct against us? I heard the other day from a relative of mine, who belongs to the naval profession, that a distinguished American Admiral, looking at the "Monarch," said to him, "Not only have we not got such "a vessel in our Navy, but in our country we cannot construct such "a vessel, because we have not the artificers; and with the difficulties "in the way of using iron which the state of the laws in America has "introduced, the difficulties of construction are ten times as great in "our country as they are in yours." And when I speak of the present condition of things, I would also point out with reference to the future, that the powers of England in construction, if we should ever feel ourselves called upon, are infinitely greater than those of any other country in the world.

What, then, is to be the process of this flotilla coming to us? It really seems almost an absurdity to consider the question of a fleet putting out from Prussia with its three ironclads, assisted possibly by Russia with four more, because, with the forty or fifty ironclads of England, they could not show their noses out of harbour. But supposing them assisted by a fleet at all equivalent, and assume them to get away for a moment, we may suppose that we should have some ships left at home. I have put before you these figures with reference to the Navy of England and the Navies of the world, and I think if they can, as I believe they can, be implicitly relied upon, there is this fact, that the fighting Navy of England is equal or superior

to all the fighting navies of the world put together. I am not counting odd ships, that you may find in Spain or Italy; because no man makes the assumption that all the countries of the world would ever combine together against one country. If that were so, no military nation would be able to maintain its independence, because no one single nation would be able for any length of time to resist a combination of all the other Powers on the Continent. No one assumes that there is likely to be any such combination of Powers against North Germany, if you did, even her present army would be wholly insufficient. When you join together Russia, Prussia, France, the United States, I think I have made an assumption as large as it is necessary under the circumstances. If after that I have shown you that we have got a residuum of ten powerful ironclads, ship for ship, I think I have so far established my proposition. Now, if you were playing the Prussian "war-game," as the Prussians play it upon land and as you may play it on the sea, and you were to put down the representative pieces to represent the naval powers of England and the naval powers of other countries, do you think they would think it worth while to throw the dice in order to calculate the chances of an expedition of this kind starting? That is again a question I venture to suggest.

Now I come to the third and last stage, that is, assuming all these difficulties got rid of—because the difficulties are a compound of simple difficulties, and they range in a sort of geometrical proportion—supposing the Prussians have got rid of our enormous superiority of fleet, what are they going to do? That again is a question upon which we should like to have some information, what is the process of disembarking a force against an enemy on shore ready to receive it? I assume this thing is not done in an instant. It takes days to prepare the expedition; it takes some time to fight this general action in which five ironclads will destroy fifty. We have made that assumption, that five German ironclads have destroyed fifty English ironclads and sent them to the bottom. The English Navy has been beaten by one vessel to ten, and it does not exist any more. Then, the expedition is ready. What is it going to do when it gets to shore? In the old days, and in the letter of the Duke of Wellington, the danger that was contemplated was that an expedition might take possession of some small estuary or harbour and would have days there to land. Speaking ignorantly on that matter, I am informed that the question of torpedoes has very much settled that, and that you can protect estuaries very well by torpedoes from the invasion of vessels in that way; therefore an expedition is more than ever reduced to the necessity of landing troops on an open beach. What is the process of landing from a flotilla of transports upon an open beach in the presence of the force that I have supposed of 30,000 infantry, 10,000 cavalry, and 50 batteries of field artillery? I should like to hear exactly from scientific men how the thing is to be done. Now, though you have sunk the British fifty ironclads by four or five Prussian ironclads, there is something left. There is a force of English gunboats, of the class of the "Staunch," which carry 18-ton guns, that can penetrate the armour of almost all the vessels in Europe. They draw six feet of water, and

you may have as many of them as you like made in three months. What would be the result of 100 of these vessels carrying 18-ton guns running a-muck among a thousand transports? I have been told by people present in the Crimea, that very few vessels making the attempt would have disorganised our landing. After all, besides the ironclad fleet of England we have many hundreds of unarmoured vessels which would be perfectly competent to attempt to disorganize the landing. Then with reference to the landing itself. I suppose the guns of the five victorious Prussian ironclads would cover the landing. Then, what I would like to ask is this, if the guns of the ships can cover the landing, why should not the guns on shore in the same way prevent the landing? If it is easy to fire two miles from sea on to an open beach, why is in not just as easy to fire two miles in-shore upon an open beach? The thing I would like to ask, as an ignoramus, is, what becomes of the first 10,000 men that are landed? You cannot land everybody at once; you cannot land all the horses at once. We know in the Crimea it took five days to land the English forces; but in the course of those five days, or three days, or four days, what would the British troops be doing? I want to know exactly what is done with an expedition of 50,000 men, supposing a hostile force is concentrated by railways to meet it, with an unlimited supply of engineers, guns of position, naval artillery, and other resources of defence; what, in the first three days, do you think would become of the first 10,000 men who are landing in boats upon an open beach? It is always assumed that they are very comfortable during that period. I would venture to ask, in the presence of the united profession, whether there are not some means known to the military arts by which it would be possible to make the first 5,000 men that land very uncomfortable. Unless there are, it seems to me that the profession has not reached its perfection yet. We know in the Crimea, for some reason or other, the landing was perfectly undisturbed. That is a very agreeable thing. But we imagine that in this country we should not make it so agreeable to the force which arrived, and that there would be some attempt to deal with them when they came; that if it takes five days to land 50,000 men before those 50,000 men did land, something would be done with them at all events. How are they going to move when they get here? Presuming that they arrived by land, of course the thing is totally different; but by sea, supposing our 10,000 cavalry have come down upon the beach, and with the help of the rural police have removed the horses and the cows and the sheep and pigs from ten miles within that landing, they would find themselves in a desolate condition, and they must rely upon what they have got with them both to feed themselves and to move themselves.

I have always heard—I know nothing about military affairs—that one of the essential things in war is to have a base, and that you must keep your communications open. What is the base, and what are the communications of an army coming by sea? I suppose it is the permanent command of the sea. Now, unless the invading army has not merely a temporary command of the sea, but unless it has a permanent command of the sea, its communications are gone; and it would be

just in the same situation that the Prussian Army before Paris would have been if the Franc-tireurs had been able to cut the line between Metz and Paris. Therefore, what an enemy must have, is not merely temporary command for a few days, or a few weeks, but a permanent command, which shall keep up his communications, or else his base is cut off absolutely and entirely; and that I have always understood is a serious matter in war.

Now I have to apologise to the Institution for having detained you so long. If in a great deal I have said I have displayed ignorance, I am perfectly ready to confess it. But I have laid these matters before you for the purpose of asking you to enlighten us, who know nothing about these things, suggesting to you the difficulties which do occur to unpractised minds on these matters, and to ask for answers to these things. If it be true that in the presence of a superior naval force invasion is impossible, surely the answer to that is, if that naval force is not overwhelmingly superior, make it so. Because unquestionably you can make your naval force overwhelmingly superior in a country like this of steam, of iron, and of seamen, much more easily than you can make your military force overwhelmingly superior. Therefore, if your force is not, upon the figures I have shown you, overwhelmingly superior, let it be made so. If fifty ironclads are not enough to fight five Prussian ironclads, let us have a hundred English ironclads to fight five Prussian ironclads, and let us feel safe if we can. If it requires a hundred English seamen to fight one North German seaman, let us retain their services, and let us be safe. Let us make up our minds as to how many English ironclads it is necessary to have in order to fight a Prussian ironclad, or a Russian ironclad, or a United States' ironclad; then let us have them, and let us be safe.

I feel how much I have to thank you for your indulgence. I have only to say, in conclusion, that the only value of this paper will be found in the discussion which I hope it may elicit.

APPENDIX.

ENGLISH ARMAMENTS.—*Individual Ships.*

Name of Ship.	Number of ton guns.						No. of guns.
	35	25	18	12½	9	6½	Total.
"Sultan"	..	..	8	4	..	..	12
"Hercules"	..	..	8	1	..	4	13
"Bellerophon"	..	..	..	10	..	2	12
"Lord Clyde"	..	..	..	2	14	2	18
"Lord Warden"	..	..	..	2	14	2	18
"Agincourt"	..	..	..	6	..	22	28
"Northumberland"	..	..	..	4	22	2	28
"Minotaur"	..	..	..	4	..	22	26
"Repulse"	..	..	..	..	12	..	12
"Royal Alfred"	..	..	..	10	..	8	18
"Penelope"	..	..	..	..	8	..	8
"Achilles"	..	..	..	..	4	22	26
"Caledonia"	..	..	..	..	4	20	24
"Royal Oak"	..	..	..	..	4	20	24
"Resistance"	..	..	..	..	2	14	16
"Ocean"	..	..	..	..	4	20	24
"Zealous"	..	..	..	..	..	20	20
"Hector"	..	..	..	..	2	16	18
"Valiant"	..	..	..	..	2	16	18
"Defence"	..	..	..	..	2	14	16
"Favorite"	..	..	..	..	..	8	8
"Pallas"	..	..	..	..	4	..	4
"Hotspur"	..	1	..	..	..	..	1
"Rupert"	..	..	2	..	..	..	2
"Viper"	..	..	..	..	..	2	2
"Vixen"	..	..	..	..	..	2	2
"Waterwitch"	..	..	..	..	..	2	2
"Enterprise"	..	..	..	..	..	4	4
"Research"	..	..	..	..	..	4	4
"Royal Sovereign"	..	..	..	5	..	..	5
"Prince Albert"	..	..	..	4	..	..	4
Total	..	1	18	52	98	248	417

Armament of remaining English Ships.

Name of Ship.	35	25	18	12½	9	6½	Total.
"Monarch"	..	4	..	..	..	..	4
"Audacious," and five sister ships	..	..	..	{10 / 50}	..	..	60
"Glatton"	..	2	..	..	..	..	2
"Hecate"	..	..	4	..	..	..	4
"Hydra"	..	..	4	..	..	..	4
"Cyclops"	..	..	4	..	..	..	4
"Gorgon"	..	..	4	..	..	..	4
"Warrior"	..	..	..	..	4	28	32
"Black Prince"	..	..	..	..	4	24	28
"Scorpion"	..	..	..	4	..	..	4
"Wyvern"	..	..	..	4	..	..	4
"Devastation"	4	..	..	..	..	..	4
"Thunderer"	4	..	..	..	..	..	4
Total	8	6	16	68	8	52	158

FRENCH ARMAMENT.—*Individual Ships.*

Name of Ship.	Number of ton guns.				No. of guns.
	22	14	8	$4\frac{1}{2}$	Total.
"Ocèan"	4	4	..	..	8
"Marengo"	4	4	..	..	8
"Flandres"	..	8	4	..	12
Nine sister ships	..	72	36	..	108
"Belliqueuse"	..	..	4	6	10
"Magenta"	..	10	4	..	14
"Solferino"	..	10	4	..	14
"Couronne"	..	6	2	..	8
"Alma"	..	..	6	..	6
Six sister ships	..	..	36	..	36
"Taureau"	..	1	..	..	1
"Cerbère"	..	2	..	..	2
"Boule Dogue"	..	2	..	..	2
"Onondaga" (not armed)	..	..	..	..	..
Seven floating batteries	..	..	28	..	28
Total	8	119	124	6	257

PRUSSIAN IRONCLADS.

Names.	Tons.	Guns.	Horse-power.
"King William"	5,938	23	1,150
"Frederick Charles"	3,800	20	950
"Crown Prince"	3.404	16	800
"Prince Adalbert"	779	4	300
"Arminius"	1,230	4	300

Two 1st class frigates, 3 turret ships, and 1 sloop are building.

RUSSIAN NAVY.

"Sevastopol" "Petropaulouski"	Same style as "Warrior," but inferior. $4\frac{1}{2}$ inch plates.
"Pervenety" "Petron Menia" "Kremlin"	Same style as "Defence," but inferior. $4\frac{1}{2}$ inch plates.
"Knaz Pojarski"	A large "Pallas." Very crank. $4\frac{1}{2}$ inch plates.
"Admiral Lazaref" "Admiral Grey" "Admiral Spindoff" "Admiral Chichagoff"	Turret ships, without masts or hurricane decks. May be classed as "Prince Alberts."
"Alexander Neffsky" "General-Admiral" "Minia" "Cruiser"	Building.

COMPARATIVE ARMAMENTS ENGLISH AND FRENCH.

English.

Name of Class of Ship.	25-ton gun.	18-ton guns.	$12\frac{1}{2}$-ton guns.	9-ton guns.	$6\frac{1}{2}$-ton guns.	Total number.
"Hercules" "Sultan"	..	16	6	..	4	26
"Bellerophon" "Lord Warden" "Lord Clyde" "Agincourt" "Minotaur" "Northumberland" "Repulse" "Royal Alfred" "Penelope"	..	..	38	70	63	171
"Achilles"	..	..	..	4	22	26
"Caledonia" "Royal Oak"	..	..	..	8	40	48
"Resistance"	..	..	..	2	14	16
"Ocean" "Zealous" "Hector" "Valiant" "Defence" "Pallas" "Favorite"	..	..	..	14	94	108
"Hotspur" "Rupert"	1	2	..	..	..	3
"Viper" "Vixen" "Waterwitch" "Enterprise" "Research"	..	..	..	..	14	14
"Royal Sovereign" "Prince Albert"	..	..	9	..	..	9
Total English armament in number of guns	1	18	53	98	251	421

French.

Name of Class of Ship.	22-ton guns.	14-ton guns.	8-ton guns.	$4\frac{1}{2}$-ton guns.	Total No. of guns.
"Ocèan" "Marengo"	8	8	..	..	16
"Flandres," and nine sister ships	..	80	40	..	120
"Belliqueuse"	..	..	4	6	10
"Magenta" "Solferino"	..	20	8	..	28
"Couronne"	..	6	2	..	8
"Alma," and six sister ships	..	..	42	..	42
"Taureau" "Cerbère" "Boule Dogue"	..	5	..	..	5
"Onondaga"	..	..	..	..	(unarmed)
Seven floating batteries	..	..	28	..	28
Total French armament in number of guns	8	119	124	6	257

Colonel Sir Shafto Adair, Bart.: I am sure, Sir, I cannot better preface the few words I shall have to offer on this occasion than by expressing what we must all feel, viz., thanks to our visitor for the opportunity he has given us of expressing our opinions on a subject of so much importance, and especially on this ground, that, prominent member as he is of the House of Commons, he will have the opportunity of informing his colleagues of what he has heard from the Officers of the profession on points of so much importance, and which in that assembly are not always as well understood as they deserve to be. With regard to the questions the honourable gentleman has put, I confess I should have great diffidence, although it is a subject that has occupied my mind for a great many years, in speaking at any length, were it not that we have already on record answers to some questions that he has put, in the department to which I shall particularly apply myself. I do not presume that I could give the answers which the honourable gentleman has requested on professional points. That would be far from me. On the general subject I will venture to make a few remarks, and endeavour to answer his questions. First of all I understood him to inquire whether the proportion between the military force of England and the military forces of other great monarchies, was so changed as to require a larger development of military power on our part than was ever necessary before. I answer in this way. It is true the preponderance was even greater formerly than it is now, but then Europe was in a state of very different public feeling, and under very different maxims of government, and appliances of mechanical force, from those under which she exists at present. I have no wish, and it would be highly irregular if I were to introduce any matter trenching on the policy of the subject as regards our relations to the Continent, and from that the honorable gentleman has very properly and judiciously warned us; but we see that whereas armies formerly were levied for the purposes of war, now whole nations are on foot; we see that it is considered in the ordinary practice of policy to imitate and to work out such principles and actions of government as is fast re-casting the whole system of the European aggregation of States. I see the military spirit dwelt upon as a civic duty. I say then, that the difference is between England as with her increased force, and her, so to speak, volunteer soldiers, and the nations of the Continent, who are now bringing every man into the ranks. As I understand, the question is, whether this could take place by surprise, whether such combinations could be made as would throw large forces against us without our having previous knowledge. Now Governments change, systems of policy are varying from time to time, and at present are very much affected by the personal characters of those who govern, and I can conceive a state of things in which a large combination, even more formidable than that the honourable gentleman has referred to, and one supplying means of transport and maritime power even more largely than he has assumed, being perfectly possible, and under certain impulses directed against our commerce and against our interests, and as a means of affecting them, against our shores. We will suppose, and we have a right to suppose, that in the great confusion that is taking place, there may be a further aggregation to the westward, and I know that that is an apprehension entertained on the Continent. I can conceive of a state of things in which channels of debouch, so to speak, against our shores, would be in the possession of an unfriendly power north of Dunkirk, and to the west of Holstein, and I know that that is an apprehension entertained in a portion of Western Europe. Then, Sir, we come to the consideration, supposing such a combination possible, of the means of transport, and the direction those forces would take. If I may be permitted to say with great deference, I apprehend the honourable gentleman has not thoroughly considered the circumstances which would probably accompany any demonstration of armed force against this country. There probably would not only be one or two great expeditions which are to endeavour to land their troops upon a particular point, but there would be subsidiary expeditions. Here I come to a fact, and for our better knowledge of this subject it will be remembered that Carnot, when he presided over the War Department under the Directory, and was carrying on that magnificent campaign in Flanders, had prepared a scheme for the invasion of the British Islands at three points, of which one expedition was to land in Ireland, another expedition to land in Sussex, and another to land in Yorkshire. I believe the expeditionary forces would be sub-divided, in order to distract attention, and to withdraw the ironclads

(on which to a certain extent I perfectly go with the honorable gentleman, as to the application of the force), from what I may call their line of battle. Supposing that to be the case, we come to the ponderation of force, and here I am sure I carry all Officers with me in saying that in military matters the operation of genius comes in after the machine is perfectly prepared; that the foundation of military power afloat or ashore is that which is prepared long before, and consolidated, tried, proved, and purified. Sadowa was the result of the battle of Jena; Sedan was the result of the battle of Sadowa. From one point of failure to one point of success, and from that point of success to a still higher point of success, the Prussians marched with a determination which carried them over three-quarters of a century in preparing to place their King on the throne of United Germany. Fortunately, as I have said, the means of applying a test to the questions of the honourable gentleman already exist. First of all, I cannot but think that what I call the transport of Europe is rather underrated. I turn to the account of the expedition to Civita Vecchia, and I turn to the account of the expedition to Algiers. I find as well as I can remember that the expedition to Civita Vecchia was prepared in three days and transported in ten; and the expedition to Algiers was embarked in three days and transported in fourteen, by 110 vessels of war, of which only 7 were under steam, and 602 transports of all classes. There stands the fact, whatever it may be worth. Now with regard to the amount of transport required, I have been at some pains to draw out a proportionate scale of the transports required for the expedition to the Crimea, and I find our forces were on the whole—our infantry, artillery, horses, guns, and stores, conveyed in one steamer, and two transports to each 1,000 men. This, be it correct or not, gives a datum from which we may calculate. Well, then, there is another point, and old Officers will be carried back in their professional recollections, and will remember that about 18 years ago there was a famous project of invasion, published by Baron Maurice, a French Officer, and translated and commented upon with great clearness and lucidity by the then Captain Addison. He remarks on the difference that steam has produced as a means of carrying on war, and whereas Napoleon the Great was restricted to one harbour, he forms his supposition under the idea that three harbours would be selected, from which three armies would invade England, the Army of Brest, the Army of Cherbourg, and the Army of Dunkirk, and he comes to England, and it ends by his placing 237,750 French soldiers in line, the purpose of the invasion being accomplished. Then comes the question, what force we have to meet them. I am now speaking of calculations, and I must refer to a work found in the pages of the "Journal," and I take a calculation which in some measure accords very nearly with that of the honourable gentleman. I take the 110,000 militia, who, I venture to think, when drilled and trained, as we have seen, will do their work well on their own soil; I take 40,000 infantry, and I find it is perfectly possible by distribution before hand, by arrangement—and that was the plan I suggested at the time of breaking up the Militia into infantry brigades, and distributing them in different parts of the country—with the assistance of the cavalry, who, I venture also to bring into line, the yeomanry cavalry, together with 14,000 or 15,000 of the regular cavalry, with the field batteries we possess, and with the militia artillery, for the purpose of fighting battles of position, I find it is perfectly possible to hold our own with what I call the statutory power within this island, and to increase it, as of course we may, to any extent. The statutory power is that which is given by statute of raising so many men during the prospect of war and invasion, without counting the masses of volunteers, and to them I attach great importance in this way. I remember a story of the French General, well known in the African war, General Changarnier. He had large masses of Zouaves, and on one occasion, his guns not being up, to clear one of the defiles held by the Arabs, he asked for his "artillery"—his Zouaves—and had it up. He said "jette la lance," threw them against the forts, and carried them by escalade. In that manner, as well as in line, the Volunteer forces of our country would be available, and therefore this brings me to the point that I object to saying that our force is too great for our requirements within our own shores. With regard to Scotland, and with regard to Ireland, the defensive nature of the country can be easily ascertained by Officers. Most of us are acquainted with it, and how well the country may be defended, that is, with regard to the actual avail-

able power. Then, it is asked why we, though being a power strong in "iron-"clads," and having to contend with smaller masses, should anticipate invasion. It must not be forgotten that England is not only fighting for herself, but she is fighting for her colonies; she is fighting for her commerce; she is fighting, I dare declare it here, for the cause of reasonable order throughout the world. I am not one who would launch this country on a Quixotic course of conquest. The days of our conquests by military force are over, but the days of our protecting the countries we have gained and our Colonies by military force, are not yet past, and I trust they never will pass away. Then, Sir, with regard to the information we may obtain, who believes in information in these matters until the fact is at their door, if there is any reason to divest their mind of it? The trader goes to his ledger, and he says, "This is my business now the 'Alabama' affair is over; we shall hear no more "about it." Every man goes to his profession, and that is the happiness of England, that every man has his special duty, which occupies his mind when he is not called upon specially to the service of his country. But we must be cautious that the great fabric which we have built up with so much care, and which, after all, though of stout materials, has sometimes rested on a fragile base, is not shaken down by our supineness. It is not that we may be called upon to put out our gigantic strength, but it is that if the belief once becomes thorough, that we hesitate to put out this force, a scene of confusion and distrust would arise amongst our industrial population, and all the dwellers in this country would have a right to complain that the Government was unequal to and had neglected its duties. I will give a case in point in this matter to show the sensitiveness of commerce. I was lately in the north of Ireland, near Belfast, and then to repeat the subject of a lecture which I gave here by permission of the Council some six weeks since.* I was dwelling on the defensive character of Ireland, and I say this by the way, when you hear of invasions by traitors from abroad, or sympathisers from the other side of the Atlantic, you may set those rumours at defiance, and hold them very cheaply. Ireland is perfectly able to defend herself, with the assistance of her loyal subjects, and such troops as the Queen can spare, against the strongest force that can be sent from any other country. That we know well in Ireland. There is the great town of Belfast, the most important of the great commercial towns of Ireland, which at this moment can hold its own, a town second only to the great towns of Liverpool, Glasgow, and the like. I had a serious remonstrance from the town of Belfast that I had not suggested any means of defending their Lough. They said, "We may be harried, as we were by Paul Jones in the last century, and we have no means of defence." My reply was that I would, to the best of my power, prepare a system of defence for that town, and I pointed out to them—and this shows, after all, that security is not very expensive—that with 46 new guns, at a cost of £65,000, the security of Belfast might be effected. I mention this to show the sensitiveness of commerce. I have no doubt whatever that in that great town, much money was lost in the interval of fear of what might happen during the American difficulty. I may say one word to our honoured guest, and it is this. He belongs to that body which has the control of the finances of this country; he will have the opportunity of hearing, as he has anticipated already in the most pleasant spirit, the professional opinions of the Officers present, who will address us on behalf of the country, and not from any idea of their own advantage; and when he returns to that body to which he belongs, and when he has the opportunity, as I hope he will have, of declaring his opinions, he will be able to tell them what the Officers of the Army and Navy think, and also what is thought by the people abroad, and that is that no sum is too large to be expended in the just defence of this country, if it be only properly applied, and well and judiciously laid out and administered, and in connection with that I am sure the honourable gentleman will do his duty.

General ADYE, R.A.: Sir, I am desirous of taking a small part in this discussion, because it is a matter of high national interest, and is one which all Officers of experience must have more or less considered. I have myself long considered the subject which has been brought forward to-night, and have listened attentively to

* "The Strategy of Invasion," &c., &c., vide "Journal," vol. xvi, No. 67, page 153 *et seq.*

the remarks which the hon. gentleman has brought forward, and I agree in a great measure with the statements he has made. I agree, I say, in great measure, but not altogether in the conclusions at which he arrives. It appears to me, if I may be allowed to say so, that the weak point of his argument is, too implicit a reliance upon naval defence; he has assumed too much that the Navy will on all occasions be round the coast of England.

The chief points brought to our notice this evening are the great difficulties of an invasion, first, the embarkation; second, the voyage; and then the landing. Those are the great points to be considered. With regard to the embarkation, we hear often in these days that wars will be very sudden, will be undertaken by enormous masses, and will give no time for preparation if we are not ready. Even as applied to land operations there are some exaggerations in such statements; but at all events, maritime expeditions cannot be undertaken without long forethought, and what is of more importance, the necessary arrangements cannot be concealed. The assembling of a sufficient number of transports for the embarkation of such a force as should have any chance of successfully attacking this country, would require time, and must be known. In the case of cavalry and artillery, the ships must be carefully fitted for the reception of the horses, guns, carriages, ammunition, and stores; even for a short voyage in a stormy sea these preparations cannot be improvised. During the Crimean war it took two great naval powers, France and England, months to assemble a sufficient force, months of notorious preparation, and although they were absolute masters of the sea, they only succeeded in landing 50,000 men, with a moderate amount of artillery and little cavalry, in the Crimea. Then again, in looking at the map of Europe, we must bear in mind that there is only one country, namely France, whose geographical position is favourable for the invasion of England. The difficulties of maritime expeditions increase rapidly with distance. When the Duke of Wellington and Sir John Burgoyne pointed out our defenceless state in 1848, our harbours were feebly defended, our army was very small, our military preparations after a long peace had sunk to a low ebb, whereas France had a great army, and a fleet almost, if not quite, as numerous and powerful as our own, and therefore they were doubtless justified in pointing out that a successful invasion under such circumstances was possible; and it is owing partially to their wise warning that our state of preparation is far more satisfactory now than then. Then as to the voyage. When an invading army takes the sea, it is at once open to the dangers of weather, and almost to the certainty of attack. Nothing can be more helpless than a large fleet of transports crammed with men, horses, guns, and stores, and incapable of striking a blow in their own defence; and no covering fleet can adequately protect them. Our Crimean experience is again an instance in point. Those who were present must have been struck with the liability of our multitude of transports to hostile attack, and Admiral Dundas, the Naval Commander-in-Chief, fully anticipated that the Russians would take advantage of so opportune a moment and attempt to defeat the undertaking. I have no doubt that our Fleet on so critical an occasion would prove worthy of their ancient renown, and although I am not competent to give an opinion on naval tactics, still I can at all events bear testimony to the great power and efficiency of the armaments of our ships—armaments in my opinion superior to those of any other power, and I am glad to believe also cheaper in cost. The third great difficulty of invasion is the landing. We are to suppose that the hostile forces have succeeded in embarking and in crossing the sea, and that having eluded or defeated our fleet, favoured with fine weather they have reached our coasts. Their position at that moment would be very precarious. If we are vigilant as we ought to be, the mouth of every harbour, of every creek, of every river, should be barred to them by means of land batteries, torpedoes, and floating batteries. The science of torpedoes is still immature, but I know of no more powerful auxiliary for defensive purposes. Therefore, I say, that with proper precautions and with the timely warning which I maintain we must have, we ought to be able to compel our enemies, if they land at all, to do so on an open beach, and to commence a campaign without a base of operations. It is at this critical moment that they should be attacked at all hazards. On landing, they must be more or less in confusion, they must be weak in artillery, and therefore whatever perils they may have escaped, destruction ought to await them on the shore.

I think I have shown that I appreciate the arguments used as to the difficulties attending an invasion of this country, but we must not lull ourselves into a false security. We must not conclude that what is very difficult is therefore impossible; we must not rely on the one line of naval defence; we must be ready on land, and we must take care to maintain an army efficient and sufficient for the defence of the Kingdom. No nation would be justified in neglecting such obvious precautions; and when we consider the present state of Europe and the extent of our coasts, 100,000 regular troops and 140,000 Militia can hardly be called an extravagant total. Before leaving this part of the subject, I would mention that the defensive modern armaments of our chief ports are now being placed in position, and during the past year, heavy guns have been sent in considerable numbers to Portsmouth, Plymouth, Portland, Pembroke, Dover, Sheerness, Tilbury, and Gravesend, and that we are to a certain extent blocking up these great harbours as I have said ought to be done. Much more remains to be done, but it is a work of giants. We must also remember that these modern appliances of war are very expensive. We have gone through a great revolution as regards *matériel* of war, and therefore for a few years the expenditure must be great.

There is one other subject which can hardly be separated from this, and that is whether this country can altogether abstain from foreign wars. Although the present discussion is limited to defence, we can hardly refrain altogether from dealing with the question of offence. I understand there is a feeling that because our Army is small, and Continental armies are large, we must for the future altogether abstain from European wars. History does not appear to bear out that view. The campaigns of Wellington in Spain and again at Waterloo, would seem to prove the contrary. In those and in other celebrated wars, we were able with our naval and military forces, and in alliance with others, to exert a very beneficial influence on Continental affairs, in spite of the great Napoleon and all his armies. As in the past, so in the future, I think we must be prepared, if necessity arises, to bear our share of the burden of Continental campaigns, although I do not for a moment advocate the maintenance on our part of the vast armies considered necessary by some of the chief powers of Europe. Standing apart as we do in the ocean, free from many of the complications which beset our neighbours, difficult of attack, and with great naval and military resources, we hold a position of exceptional advantage, but in my opinion we ought not to attempt a policy of selfish isolation, and I doubt if such is in reality possible. As one of the family of European nations, we cannot absolve ourselves from the duties and responsibilities of that position.

Lieut.-Colonel CHESNEY, R.E.: I shall say a few words, confining myself as strictly as I can to what is laid before us, but it is impossible in the time allowed or indeed in any reasonable limits, to answer each point fully, as any one must know, who has heard the series of questions. I shall therefore only touch very slightly upon one or two of them, and in particular I would make one important correction—the only important statistical correction I shall venture on what Mr. Harcourt has said—as to the number of horses that would be used. I do not profess to be in the counsels of any chief of the staff of any foreign power, but I am quite certain that if one of the chief military powers now dreaded, was intending to attack us at present, the proportion of horses brought over would be infinitely smaller than that put by Mr. Harcourt. If 30,000 men came over from Germany on such a mission, I do not think at the outside they would attempt to bring with them more than 5,000 horses. They are quite as well aware as we are, of the difficulty of carrying horses, and it is their way to adapt the means that they use to the object in view.

Passing from that I come at once to the fourth question. When I said I was going to speak to-night, Captain Moncrieff who is behind me, suggested a point already in my own mind as to the way in which England might be surprised, and I will add to what he suggested a special consideration. We are governed in this country immensely not only by the power of the Legislature, but by the power of the press. If we were engaged in a war with a powerful maritime nation at the present moment, and any one of our great ports suffered seriously, the outcry would be instantly such, that our Government whether wise or foolish, prepared or behind-hand, would be compelled to hurry to that point which was being annoyed or attacked, a very large portion of the defensive forces of the Kingdom. Now it is not to be supposed that

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Passing from that I come at once to the fourth question. When I said I was going to speak to-night, Captain Moncrieff who is behind me, suggested a point already in my own mind as to the way in which England might be surprised, and I will add to what he suggested a special consideration. We are governed in this country immensely not only by the power of the Legislature, but by the power of the press. If we were engaged in a war with a powerful maritime nation at the present moment, and any one of our great ports suffered seriously, the outcry would be instantly such, that our Government whether wise or foolish, prepared or behind-hand, would be compelled to hurry to that point which was being annoyed or attacked, a very large portion of the defensive forces of the Kingdom. Now it is not to be supposed that

any reasonable soldier of any foreign nation would prepare to make a real invasion of England without trying one or two false invasions elsewhere, if indeed he did not make other serious ones.

I will go on to say a few words as to the last question, the most important of all. "Have the recent changes in the nature of armaments, as for instance, the introduc- "tion of steam, guns of precision, armour-plating, and torpedoes, increased or dimi- "nished the relative defensive power of England?" The answer to that is a plain and general one, and rises much beyond the subject we have before us. It is that the increase and the vast development of mechanical means, and of organising power which we have witnessed in the last half century, while it has made an advance in locomotion such as no one could anticipate, has also infinitely increased the advantages of those who make war. In that one point lies the great mistake of all those who have counted on eternal peace; they never recollected that the very means which they so hailed for bringing men, and the things which are useful and pleasant to men together, would also serve the purposes of war equally well. I have not the slightest doubt—without entering into any of those statistical details which would prove or disprove anything—I have not a doubt that any one who seriously considers the history of the last fifty years, must see that the power of making war has increased to an extent which Napoleon could not have dreamed of. It has been said before me by intelligent German Officers that Napoleon, had he had but one railroad at his command in 1812, would have conquered Russia with ease. I merely put that forward as one observation touching this sixth question. Apply it to the general subject, and you will see what I mean. But it was also Napoleon who said, what people who lecture upon war so constantly forget, that the "moral power in war is to "the physical as three to one." The moral sense of nations seems to me on this subject of invasions to be altogether changed. I will prove this by an example, and a very simple one. I spent a long day's travel lately in company with a very agreeable gentleman in Wurtemberg. I told him I was an English Officer, and he told me he was a manufacturer near the capital of Wurtemberg, one of the most peaceful parts of Germany, dwelling wholly inland, and living by manufactures entirely. He employed about 200 workmen. We got into considerable mutual confidence, and discussed military matters, of course speaking of the war. Just before we parted at a station near Stuttgardt, he said, "There is one question I "should much like to ask." I said, "I will answer it if I can." "There is," he went on, "a great deal of talk in our newspapers frequently about the invasion of "England. I should like greatly to know what is your professional opinion as to "the possibility of its being accomplished should such a thing be tried?" I passed from that man's society to go to Berlin. Near the west end of Berlin I saw before me apparently a new palace of handsome architecture and enormous size, about half the size of Somerset House. I asked what this was, and the reply was, "Oh, that "is the office that is built for the General Staff of our Army." "I suppose," I said, "that is where the administration of the Army is carried on?" "Oh no, it "has nothing to do with that; it is simply an office for Count von Moltke and his "personal assistants, and their library, to work out their plans." Now I have the greatest possible respect for Count von Moltke and his assistants, but I do not want to put before them voluntarily the problem which it seems to me would be put before them if we followed Mr. Harcourt's line of reasoning. For if we admitted that our 51 or 101 ironclads are to be held sufficient to defend our shores, the argument would not go to reduce our Army to 30,000 infantry, but it would leave us without any army at all; it would leave us simply dependent upon one line of defence, and it would put before an enemy the one single problem, how can you overcome or destroy temporarily this one line of defence; for this once destroyed, England falls? I had not intended to refer to a certain well known story—but Mr. Harcourt spoke of the Battle of Dorking, and what he has said compels me to do so, because he stated that the author supposes that there is no fleet. (Mr. Vernon Harcourt: I said he had assumed the landing.) The author not only assumes but explains the landing. The English Fleet existed in its pride and strength in that story, but the English Fleet is supposed to be destroyed by some suddenly developed means of offensive fighting at sea. It seems to me a marvellous example of prescience, that at the time the author wrote he was not aware that in two different har-

bours of Germany there were constructing fleets of torpedo boats—not prepared against us—built with the intention and object, and with the great probability of destroying the French Fleet had the war lasted any longer. Surely this alone shows that it would not be fair to leave the whole country dependent upon a single naval line of defence, and to say to all the world, " If you can discover some means of destroying " our fleet, we place ourselves at your mercy, and give up for ever our position in the " world."

Mr. Foggo: Mr. Chairman, if a non-member may be allowed to say two or three words, I should like to take the liberty of saying those two or three words. It appears to me that the honorable and learned gentleman has established a very great degree of improbability of an invasion of this country, but not, as I understand him to contend for the impossibility of it. I think—I say it with great deference—that he has not taken into account what I may call the unforeseen, the ordinary unforeseen. Now may I ask him what would happen in the event, for instance, of another Indian mutiny, which might deprive this country of a very large number of our standing Army? Then, in the second place, supposing an attack were made upon the Dominion of Canada, that would take away a large portion of the standing Army, as well as a large number of our ironclads. Again, under either of those circumstances, of an Indian mutiny, or an attack upon the Dominion of Canada, there might be a general combination amongst the European Powers, and that would, it seems to me, in a great measure, or to some extent, do away with the difficulties of transport. The other consideration that occurred to me was this: when the honorable and learned gentleman spoke of the certainty of our not being taken by surprise, and of our being able to station the "Great Eastern," or some ironclad, close to the port where the expedition against this country was being prepared, it struck me that it was not entirely beyond the range of possibility that we might be so—I would say, morbidly averse to a declaration of war—that we might possibly wait to see the enemy's ships start from the port before we thought it right to declare war.

Dr. Hamilton: I shall not detain you long, but it strikes me that there is one fallacy which runs through the whole lecture which the learned gentleman has so kindly done us the honour to give us this evening, as well as the addresses of those Officers who have spoken, and that is this: that the honourable and learned gentleman takes it for granted that whatever enemy attacks us, whatever combination there may be among the Powers of Europe, they will attack us just at the time that suits us, and not at that time which suits themselves, in fact that their first act will be an invasion of this country at the very time when we are in the flush and pride of our power and strength. But how would it be, supposing there was this formidable combination which the learned gentleman has alluded to, and that there should be a twelve months' or two years' war before this attack takes place. Suppose a combination in which the United States should be an element, we know perfectly well the way we should be situated then as regards our Colonies, both as to Canada and our more distant possessions. We must fight to protect those colonies, we cannot stand by and look on, and therefore I think it would be worth while for the learned gentleman to take that into consideration when he next considers the invasion of this country. That is, how we should be after a war of one, two, or three years, and should we then be in a position to repel attack?

Captain Jasper Selwyn, R.N.: I rise to ask whether this discussion can possibly be closed this evening, and, if not, what time would be at our disposal for discussion hereafter, as I, for one, believe that there are a great number of Naval Officers and others present who are quite ready to prove, to Mr. Harcourt's satisfaction, that many of his bases are utterly fallacious and ungrounded? I particularly refer to the question of " transport " as one of the things which I myself am prepared to prove, if the meeting is of opinion that we can go on a sufficient time, otherwise I beg to move the adjournment of the meeting.

The proposal for adjournment having been seconded by Commander Dawson, R.N., it was arranged that the meeting at its close should be adjourned to Wednesday evening, June 5th.

Captain Selwyn: I will now begin by saying that the question of armaments in this country has been too often mistaken so far, that we have got to consider the phrase of " bloated armaments " as one of every day occurrence. I want to show that ar-

maments are a mere question, first of all, of an insurance on the increased wealth of the nation, and that if you do not consider them in that way, you will never arrive at a just conclusion as to how much you ought to expend on those armaments. The question the lecturer has asked, "why our land forces should be doubled" is, I think, to a certain extent answered by that fact alone, that our temptations to invasion have not only more than doubled, more than trebled, but have increased in an enormous and unprecedented ratio. But were that not the case, there would be still the other reason, that the rapidity of movement, the suddenness with which surprise may be forced upon us, has also increased in a ratio which we cannot estimate. Now, I am going to show you on conclusive evidence that we certainly shall very ill appreciate the powers of offence against us if we do not take into account the changed state of foreign nations. It has fallen to my lot lately to consider the lines of steamers going out of Europe. There are at this moment, and there are every day of the year, lying in two ports of Germany, enough steam-transport in the shape of 3,000, and over 3,000 ton vessels, to bring an army of 60,000 men to our shores. They are lying there, and their force is increasing also month by month from our own shipbuilding yards. The very best vessels that can be constructed in this country are sent over to carry on that great stream of emigration which goes from the northern ports of Europe.

Mr. Harcourt: Will you give us the facts, for they are very important? I attach great value to facts. I suppose you refer to Hamburgh and Bremen?

Captain Selwyn: To Hamburgh and Bremen alone, without counting Stettin or any other ports. Each steamer is either of 3,000 or 3,500 tons burden, and can carry easily 3,000 men for a voyage of 300 miles.

Mr. Harcourt: Will you kindly tell me how many vessels of 3,000 tons there are at Hamburgh and Bremen?

Captain Selwyn: According to the published list there are 25 vessels belonging to those two lines, without counting any of the other American lines. (Mr. Harcourt: There every day?). And they are of 700 horse-power. There are only two vessels out at a time out of the 25. There is a much larger number there really; but those are the prominent vessels. I am speaking now of two lines of steamers alone. They are merely transports, as any seaman will know, and they carry easily 2,000 emigrants stowed away in bunks.

Mr. Harcourt: You must allow me to point out that 300 vessels of that size were employed to carry 15,000 men to Abyssinia.

Captain Selwyn: We never have had 300 vessels of that size; those are the first vessels of their size and power.

Mr. Harcourt: There were several vessels employed above 3,000 tons in the Abyssinian expedition.

Captain Selwyn: None of this power or carrying capacity, because they have new engines and new means of carrying coal. The next point with regard to that question of landing is, that those vessels have behind them at all times a *corps d'armée* of the number required, existing in those districts of Germany alone, and belonging to those districts, always there and always ready to be embarked at a very short notice, and we certainly should know nothing about the internal arrangements of the Germans as to marching down troops to their ports, they would take very good care of that. It is not to be supposed that they are going to tell us either when they are coming or where they are coming, which is much worse because, we have many hundred miles of shore to defend, and we do not exactly know which part they are coming to. Now, there happens to be a part of the coast of England which I should dislike particularly to refer to, but it is as nicely situated as possible for Germany. I do not want to teach everybody exactly where it is, but you can run the whole of your steamers' noses on to the beach without the slightest danger, and land every man over their bows; and gentlemen who fancy that landing is to be done as it was in the Crimea forget that, generally speaking, military and strategical reasons have forced sailors to land on beaches which they did not like, and that we must take into account, as the Germans are not such *dummenkopfs* as to fight the sailors on their own element, and tell them what to do, they will probably take their advice as to where a landing had best be effected. The blockades which were spoken of, involved the necessity of your steamers blockading that port, having full information as to what port was of importance. If that full information

existed, if you could get all those ironclads of which mention has been made, manned and ready and started within a few hours' notice and they knew where to go to, some such idea might be possible, but that is not the case; and I do not see how you are to rely on ironclads which first may have been drawn off, as the other speakers have said, but which, secondly, do not know where to go to, are not ready, are not manned, and in most cases and in most times we have not the men to man them with and barely the guns to put on board. I do not want to go at length into this subject, but there are common precautions which can be taken, and which ought to be taken, for defending our shores. I do say it is scandalous that to this hour we have not got from 8 o'clock at night till 8 o'clock in the morning, any communication by telegraph between any coast guard along the shores and head-quarters. That is a precaution which is worth more than many ironclads, many soldiers, and many sailors, for it is early intelligence, and without that, the whole basis of your defensive power is in the air. We ought to be able at once to telegraph from any part of the coast at any hour of the night, any suspicious appearance off the coast. We are not able to do it, and I hope that will be a subject to which this lecture may draw attention, and that we shall not repose in fancied security on the showing of the great power which could be brought to bear, *if* all our forces were ready to oppose the enemy immediately he showed himself at that point.

Mr. Vernon Harcourt: I should like to make five minutes' observations before the discussion closes this evening, as that may assist future discussion?

The Chairman: Perhaps Mr. Harcourt will allow me one word before he proceeds. There is one point, namely, that there were 400 ships which took the expedition to the Crimea, in which I think you are wrong as to your numbers. I hope you will be able to show that you are right; but I do not think there were so many ships. My impression is that there were 31 sail of the line, and 28 steamers towing 50 sailing vessels.

Captain Hoseason: I think Mr. Harcourt has added the French to the English ships.

Mr. Harcourt: I looked in M. Bazancourt's work, which gives the French transports very accurately. Mr. Kinglake's work, which is the only work I had, gives no numbers of the English transports. I looked in the "Annual Register," which gives 400, and also to some articles in the "Quarterly Review" as to the number of transports, and from that I stated it. If we can get accurate information upon that it will be very valuable. I have no means of getting authentic information. Of course the information of the "Annual Register" is not authentic.

With reference to the first observation made, the expedition to Civita Vecchia was mentioned. That was an expedition with no naval force to oppose it, and there the troops were stowed, as the French have often stowed them, "like herrings in a barrel," on board their line-of-battle ships. That I put out of the question, because if you are going to have a fighting expedition you cannot stow your men like that. That is true also of the expedition to Algiers; but what Colonel Adair mentioned is very valuable, as showing the length of time taken. He mentioned that it took ten days to go to Rome. The ordinary passage to Civita Vecchia I suppose would be two days; then you have a military expedition, which takes ten days going. To Algiers it takes fourteen days; that shows the length of time which is taken when you have even such a moderate flotilla as that. That is important. Colonel Adair said that there was one vessel to a thousand men in those expeditions. (Colonel Adair: One steamer and two transports is my calculation to every thousand men). With reference to Mr. Bazancourt's figures it was very different from that, because those figures I can rely upon taken from his work, and you will find the numbers very accurately given. There were 48 vessels of war of the French, of which a large number were three-deckers, towing 49 transports; that is 97 vessels, or say in round numbers 100 vessels to carry 25,000 men, and that is one vessel to 250 men, instead of 1,000, and that though you are employing line-of-battle ships for the purpose. With regard to the English transports I have not the figures. The French unquestionably stowed all their men on board the line-of-battle ships, and, besides that, they had 16 transports towed by Turkish men-of-war. Practically speaking the French had, including the great three-decker line-of-battle ships, one vessel to every 200 men. (A Visitor: Each of these line-of-battle ships,

the three deckers had 1,100 men of their own). These are the figures according to Bazancourt's book: Infantry 25,000 men, Artillery 2,000, Engineers 800; 1,500 horses, 68 cannon, 48 vessels of war, 49 transports, 16 transports towed by Turks. Those are the figures. Of course I cannot test them.

Now to pass to another point. It is said that we must defend our colonies. So we must; but how are we to do so? We are to defend them by sea. That is the question for the Navy. With the exception of Canada, all our colonies must be defended by sea, and, therefore, every argument which applies to an attack on our shores, applies with tenfold force to the attack on our colonies. No doubt you must detach a part of your Navy to defend your colony. Then arises the question, why do you detach part of your Navy? Because part of some other navy has gone there. Therefore you come back again to the whole question of the gross naval force. A detachment is a detachment as against some detachment from the other powers you have to deal with.

Colonel Chesney remarked with reference to the small number of horses the Prussians would bring. He said they would bring 5,000 horses. I take his authority on that subject, and I ask what is an army with 5,000 horses going to do in the presence of another army with 10,000 cavalry and 50 batteries of field artillery? How are they going to move? What are they going to do. All I can say is, if the Prussians come with 5,000 horses because of the difficulty of carrying them across, they must have altered their views as to the use of cavalry in this country. What are they going to do? An army with 5,000 horses all told, carrying its baggage and ammunition, everything it has got—is to meet an English army with 10,000 cavalry. How are they to poke their noses out of a beach on which they landed with 10,000 cavalry sweeping round them? One of two things happens: either the expedition is embarrassed because of a great number of horses, or, if it gets rid of that embarrassment, it cannot move because of the greater number of horses which the enemy has. It is said mechanical appliances have increased the powers of attack. Every one admits that; but has it not increased the power of defence? because that is the point that Colonel Chesney did not deal with. Take torpedoes, for instance. Have these increased the power of defence or attack most? (Colonel CHESNEY: Both). That is a question for scientific Officers to answer. My impression would be that they had increased the power of defence first. I should have thought the Thames more defensible since torpedoes have been invented than it was before. A distinguished relative of mine, a Naval Officer, told me that he believed the main use of the forts at Portsmouth would be simply as points for working torpedoes from; for all other purposes they were actually useless. That shows that torpedoes have increased the power of defence, because they have made the new forts of Portsmouth utterly useless. That is the opinion of many people.

Another point put by Colonel Chesney was, if the fleet is destroyed, and if the argument of naval force is good for anything, then it ought to dispense with an army altogether. But let me put the other side of the argument. If you assumed the fleet destroyed by one of those sudden developments which Colonel Chesney referred to—I cannot deal with sudden developments, because those are things I know nothing at all about—but if a Vesuvius arose all round the British Islands and blew up all the British Fleet, well then it is not 1,000 men that can defend England, or 100,000, you must have a million, because if your fleet has gone, there is no difficulty in landing. 100,000 men are of no use; there are a million of men on the Continent, and you must keep a million of men in this country; if you assume the entire destruction of the British Navy, it is no use having 100,000 men when France and Prussia together can easily send a million. Therefore, once assume the entire destruction of the fleet, and it is child's play to talk about 100,000 men. And that really is an answer to another gentleman who says I have not taken into account the unforeseen. That is a process I do not profess to understand. The hypothesis rather involves that a thing when it is *unforeseen*, is one that you *cannot foresee*, and to speculate upon the unforeseen is a thing that I confess is out of the province of my profession, though perhaps it may belong to the military profession.

With reference to Captain Selwyn's remarks, I thought I was going to be overwhelmed at least by facts, and I was told that every day there were in Hamburgh

and Bremen enough shipping to embark an army as I understood of 50,000 men; but it comes down to this, that there are 25 vessels.

Captain SELWYN: I said belonging to two lines; there are twenty lines going.

Mr. HARCOURT: Twenty lines! The point I wanted to arrive at is how many vessels.

Captain SELWYN: I have given you merely the vessels belonging to two lines of steam ships which exist. (Mr. HARCOURT: Transatlantic?). They are not the South Atlantic lines at all; they have nothing to do with these, only to do with the two lines that run across round our shores.

Mr. HARCOURT: This is a question of fact, and it is a very important fact. It is a matter I have looked a little into; the mercantile marines of Europe are almost as important for the purpose as the fighting marines. This is a matter which may be ascertained in the course of a fortnight, and all I can say is—(Captain SELWYN: I have the list of vessels in my pocket)—I will give up all my questions and all my arguments if there exist in Hamburgh and Bremen one-half, and would almost say one-fourth of the number of vessels actually employed in transporting 15,000 fighting men to Abyssinia. (Captain SELWYN: Perhaps you will pardon me for pointing out that a vessel that has to carry coals and provisions to Abyssinia, is under very different conditions as to what men she can carry, to what she is when she has only to cross 300 miles of sea). That is quite true, but we know what the vessels carried when they went from Varna to the Crimea; but if any gentleman will look in the report of the Abyssinian Committee, he will see that there were vessels of 3,000 tons and upwards occupied in that transport, and if he will examine the list of those transports, and compare them with the mercantile marine in Europe, I will venture to say that the collective mercantile marine of Europe does not equal the number of vessels actually employed in the transport of that expedition. (A VISITOR: That was in a tropical climate). That is a point capable of being verified. It is a very important matter, and let us have it correct.

There is only one more observation that I will reply to, and that is a very important one—"that you cannot tell where the expedition is going to." I imagine when an expedition of that sort goes as slowly as we have already seen the expedition to Civita Vecchia went, it would be followed by swift despatch boats, who would be constantly keeping your fleet informed of their movements. This question of transport is a most important one, and I think, before the next meeting, it would be well to verify the fact as to the transport power of North Germany.

The CHAIRMAN: Before we part I hope you will allow me to thank Mr. Vernon Harcourt; for these questions are most important questions for the consideration of the general question, which is a subject Mr. Harcourt has rather avoided, and which I think perhaps he had better avoid. He has brought it forward in the most technical, the most military, and naval point which can be of interest to us. I think he calls upon us very properly, laying down general principles which are those he thinks right, for details to beat those principles; and therefore I think if we can bring facts either of the experience gained in expeditions to Egypt, to the Crimea, or even the invasion of England, at the various landings that have taken place, and can show that such things have taken place, and they are capable of again taking place, those are the points upon which Mr. Harcourt will be glad to have real information, and he will then form his opinion, and will be honest enough, I believe, to form his opinion truly. I thank Mr. Harcourt in your name for his kindness in coming here to-night.

Wednesday, June 5, 1872.

ADJOURNED DISCUSSION ON MR. VERNON HARCOURT'S PAPER.

MAJOR-GENERAL EARDLEY WILMOT, C.B., R.A., in the Chair.

The CHAIRMAN: Gentlemen, before we proceed to the adjourned discussion on Mr. Harcourt's paper, he has asked for a few minutes to make a short statement and a few corrections in the paper which he read.

Mr. VERNON HARCOURT: I shall confine myself entirely to figures, just to correct

some of the figures which I gave before. There was a discussion (and I have no doubt we shall hear a great deal more of it) on the subject of French transport. The figures I gave of the French transport in the Crimea were taken from the separate volume of the "Annual Register," and from Bazancourt's work. The French expedition was composed of 15 ships of the line, 11 frigates, 14 corvettes, 5 other vessels, and 3 commercial steamers. That is 48, all used to serve as transports and towing 49 transports. They carried 28,000 men, 1,437 horses, and 68 cannon. Besides that, the Turks had 16 vessels of war towing 16 merchant vessels; that is 32 vessels in all, and they carried 7,000 Turks. The English expedition, of which I gave the figures loosely and very inaccurately, I have now had the opportunity of taking from Admiral Sir William Mend's paper read before this Institution. It appears that that expedition had 88 transports; that they carried 32,000 infantry and artillery, 1,240 cavalry soldiers, and 3,349 horses. Those are the figures that I find in Sir William Mend's paper.

I should also like to add some other figures which I have obtained, as I think they may be of use in the discussion. I dare say it is within the knowledge of many Members of this Institution, that recently the Government have been carrying cavalry from England to Ireland by sea instead of by railway, finding it more economical. I thought it was valuable to know what was the tonnage employed for that purpose, and the figures I have are these: ten vessels of 6,244 tons; in all 953 men and 835 horses carried. That gives an average of 600 tons per vessel, and the 6,000 tons carried altogether 953 men and 835 horses. You will find that that is on an average 95 men and 83 horses for each ship of 600 tons; or, if you take it in another way, 160 men and 140 horses per thousand tons. That is the recent experience of the carriage along the coast from England to Ireland. I have also a calculation of what may be done in the form of the new transport service. It is estimated that a ship of 1,500 tons, which I believe is now building, will carry a regiment; that is to say, it will carry 1,200 men of the foot regiments; and if you use it for cavalry instead of for infantry it would carry 138 horses and 200 men. That is what a ship of 1,500 tons is estimated to carry. Of course I need not say that that is without stores for any length of time; the carriage is only from England to Ireland.

There is another point which I should like to clear up. Question has been raised as to the numbers which I stated as to the troops at present in England. I believe the figures I gave were correct, but I should like to give them again so as to show exactly, as it was an important element in the discussion. At present in the United Kingdom there are 13,000 cavalry soldiers; that is to say, there are 1,292 household cavalry, and 11,889 cavalry of the line. There are 18,000 artillery,—3,000 Royal horse artillery and 15,000 Royal artillery,—that is the actual force in the United Kingdom. There are 4,128 Engineers, and there are 66,000 infantry, of which 6,521 are Foot Guards and 59,477 infantry of the line. I do not include the Army Service and the Hospital corps. That will make altogether a little over 100,000 men of all arms, cavalry, infantry, artillery, and engineers. That is the fact with reference to the existing force in the United Kingdom. As regards horses, I find there are 848 horses for the Household Cavalry, 6,757 for the cavalry of the line, 2,000 horses for the Horse Artillery, and 4,000 horses for the other artillery, and then other horses belonging to the other forces which I need not detain you with.

There is only one point more and it is so far a new point. I do not know whether any notice will be taken of it to-night, but it is a point I have recently raised, and I should be very glad if any one will discuss it. I have endeavoured to obtain an estimate of the annual cost of a first-rate iron clad like the "Devastation." I find the cost of the "Devastation" was £300,000; that the estimated wear-and-tear of hull and machinery might be taken at £16,000 for the hull, and £5,000 for the machinery; that her complement of men is 250; that the pay is £11,320, and the victuals £4,500. If you take that and divide the cost of construction by ten years, that would be £30,000 a year for the construction, £20,000 for the repairs, £12,000 for wages, £5,000 for victuals, and I add to that £3,000 for coal and other expenses, which would give altogether according to that estimate, the cost of building and maintaining such a vessel as the "Devastation," at £70,000 a year, were it to exist for ten years only and then to become superannuated. I venture to supply those figures as they might be useful in the discussion.

The CHAIRMAN: I will just call the attention of the meeting to the fact that there are a great number of Members who wish to address the meeting this evening, and, therefore, it will be absolutely necessary that all speakers should, as far as possible, confine themselves within the limit allowed for discussion, namely, ten minutes.

It was here ruled by the Chairman in reply to a question by Colonel Strange, F.R.S., that the discussion should be confined to the points brought forward in Mr. Harcourt's address, and not be extended to the letters which had appeared in the *Times* between the 15th May and that evening.

Captain SELWYN, R.N.: Mr. Chairman and Gentlemen, on the last occasion I advanced a proposition which I am here to-night to support. I have put before you on these two slates an accurate list obtained from Germany of the steam vessels then mentioned and their tonnage (the registered, not the real tonnage), and, in the case of the Norddeutscher Lloyd, their horse-power, also showing the number of vessels that belong to those two lines, and which are in active use to-day. I perhaps may have stated rather too much if I said that two only were out at a time, but I viewed it in this light, that two only are leaving at a time, and that the very slightest turn of politics would induce the retention of all the vessels going out, and the detention of all those which came in, and that consequently this tonnage might be regarded as available within a very short space of time. Enormous as it is, it is far beyond any possible requirement for transport of any army that would invade England. These vessels I am prepared to say, after consultation with the best authorities in the city on matters of steam shipping, can carry easily each of them 3,000 men, the Board of Trade regulations being fully complied with, and I need not say that these regulations involve the use of very much more space than would be required by well disciplined troops. Here are 36 vessels belonging to two lines, averaging 3,188 tons each. There are 15 more building for the Norddeutscher Lloyd line in our own ports, there are 4 more building for the Hamburg American line. Now then, will you consent any longer to listen to anything like the shams which are involved in saying that the question of transport remains where it was 20 years ago? Will you consent to consider for one instant the transport of troops in sailing vessels, or in small steamers for long distances, as to be fitly compared with the possibility of transport in these ships from a port certainly not 300 miles away from your own shores. I beg to draw attention also to the fact that these vessels belonging, as they do, to ports where a small draught of water is absolutely necessary, differ enormously from our own ironclads designed for the protection of coasts where shallow water is the rule and deep water the exception. They (the ironclads), unfortunately, draw very much more water than any of these ships; 18 feet is the draught of water of these vessels, 18 feet loaded with cargo, coal, and everything else for an American voyage. That compares very ill with those floating forts which may have their use in deep water, if they are not drawn away by a cleverly devised feint. But it is very easy to see that even when arrived at some points they may be of very little use if shoal-water and not deep-water points were attacked. I need only ask naval men to consider and to ask themselves what would be the result of a telegram to our outports to-day to assemble a fleet on any point of our shores—how long would they take to get there? or how long would they take to be manned and prepared? Perhaps I might go back still further, how long would the intelligence be in reaching the port? how long would it take in reaching London? Early intelligence is at the base of all success in war, and if we ignore that very first point of our defences, we shall do very unwisely indeed. I am not an alarmist, gentlemen, but I stand here to say that it is wise to consider how many shams there are in existence, how many things you are trusting to, which will break down under you, or pierce your hand when you lean upon them. I want that England should never have panics, and she never will have panics when she knows thoroughly what she has to rely upon, and relies thoroughly upon it. That can never be done without active exertion, without such knowledge as Mr. Harcourt's paper is calculated to draw out. I presume he came here for answers, and we are bound as professional men to give him those answers candidly, straightforwardly, even if they involve a reproach on our own profession. We cannot secure the country with the means now given us. Ironclads are well devised as floating forts, and ill-devised as coast-defence ships. I am not alone in that belief. The Royal

Commission reported precisely in the same direction; they said, "You cannot rely upon them, and therefore you must have fortifications." Where will you place your fortifications? Are you quite sure that your enemy will choose the points fortified at which to effect his debarkation? Let us then consider, and consider closely, all the possibilities of the question. I hope others will follow me, showing whether I am correct or not in estimating the number of men capable of being embarked. The question of debarkation I spoke of, and I was reluctant to point out to a possible enemy in the future, the exact spot at which this could be done; but I affirm again that there are 20 miles of coast in one place,—I do not say that there are not 20 miles in other places,—there are 20 miles of coast in one place where I will engage to run the whole of these transports, with their noses on the beach, and debark the whole of the troops they contain, in less than four hours. If you give us seamen, a low, long beach as the point of debarkation, and involve us in the question of putting troops, artillery, and cavalry into boats, and then taking them to the shore, we shall only do what is possible under those circumstances; we shall do what military men ask us to do, but that will not be what a seaman would do. If you ask us, on the contrary, to put our ships on shore with full command of steam in deep water, with no fear whatever, we will do a very different thing, and we will show a debarkation that has never yet been equalled in the world, and I presume what we can do, seamen of other nations well instructed, closely educated for the purpose can do also, at least it is not wise to except the possibility.

I have given you, then, the ships and their tonnage; everybody can read and verify them for themselves. If there be any error it is a perfectly involuntary one. I have sought the best sources of information, those, I am sorry to say, which do not seem to have been open to our own authorities, since the Institution was furnished through the kindness of the Board of Trade, with their reports up to the latest date, and I find that about one-fourth of the tonnage contained in this list of steam ships is ascribed to the whole ports of Bremen and Hamburg in the Board of Trade returns. I mention that to show how utterly fallacious bases will be, if they are taken on information so given. I think Mr. Harcourt also gets hold of a fallacy in thinking that the "Devastation" could be run for a certain price. He left out a very important element, which is that of galvanic action, and in which some of our ships not only cost more than he says for their repairs, but they actually go out of existence. The "Monarch" is reported to require £16,000 to be expended upon her to fit her for a four-years' longer cruise. (Mr. HARCOURT: I allowed £20,000 a-year for repairs for the whole ten years). Of a ship costing £300,000. These are the repairs we get in one year, and I do not know what it will be in the next year. It will make her last a time; very probably it would. It is not satisfactory; it is a case which requires very closely inquiring into. There is one thing we certainly might do with these vessels. The Americans seem very fond of large ships, and I should suggest that as our cousins are quite ready to buy anything, particularly anything big, we should hand over to them all these useless vessels which we cannot use ourselves, and say, "Perhaps you on your deep-water shores can find a use for "them, but we have none on ours." If we want really to defend our coast it must be done by local defence, it must be done by careful concentration of the greatest power in small boats, habitually used by, and known to, the seamen at each port, and not by an accumulation of ironclads which dare not go into those waters where they are required.

Commander W. DAWSON, R.N.: I am prepared with some statistics to bring before you with reference to the question of transports. I agree with the learned lecturer in many of the conclusions at which he has arrived, at the same time that I disagree with many of the premisses on which they are based. The questions put to us, assume that the Army exists chiefly for the purpose of repelling invaders; but it exists rather to prevent possible foes dreaming of the possibilities of invasion, just as policemen are to prevent burglaries rather than to capture burglars. We have not been invaded since the time of William the Conqueror; yet the British Army has had a good deal to do since that time, and many Officers in this room have been employed against a foe, and have written history with their swords if not with their blood, who did not serve under Harold. (Colonel CHESNEY: William the Conqueror or William the Third?) William the Conqueror; William the Third was not an

invader, but a deliverer. The first question put to us is, "What are the character "and extent of the preparations necessary in order to such an enterprise as the "invasion by sea of a country possessed of a powerful fleet?" My reply is, that the first preparation is to get permanently rid of the British Fleet. Invasion cannot take place after merely getting rid of the Fleet for a few days or weeks. The invader must defeat the British Fleet, or get rid of it in some way, for a certain number of months. The defeat of the British Fleet may at this moment be an improbable contingency, but looking forward to futurity, we have no reason to suppose it to be an impossibility. When Charles the Second ascended the throne of England the British Fleet was in a much prouder relative position with reference to the navies of Europe than it is at this moment; but before that Monarch ceased to reign, we had to sink our ships at Sheerness in the vain attempt to prevent an enemy's fleet ascending the Medway and burning the dockyard at Chatham. There is no reason why history should not repeat itself. Last year the most magnificent army of Europe was found so well organised for defeat, notwithstanding numbers and appearances, that it melted like snow before the summer sun. If, at some future day, corruption, false economy, or over-weening confidence should organise the British Fleet for defeat, defeat will come, but it must be organised for it from within. The very first step for that purpose would be to endeavour to persuade the seamen and Officers of the British Fleet to believe what has been recently dinned into their ears by a portion of the press and by certain authorities as to seaman-like skill having been banished from the Navy three years ago, and as to there being no skilful Officers left; if the Navy would but believe those statements, depend upon it the nerve and pluck will banish from those iron hearts which are quite as essential for the defence of the country as ironclads.

As to question 2, "What would be the amount of shipping, &c., required?" I quite agree with Colonel Baker* that 3,000 infantry soldiers can be carried in a first-class merchant ship, but I think that when we are investigating questions of this kind it is not safe to take a first-class steam ship as a standard, we ought rather to take a second or third-class vessel. I have therefore endeavoured to estimate the transporting power that would be required, not only in ships but in tons, for such a force as Mr. Vernon Harcourt assigns to the invader; and comparing the estimate thus made with the tonnage employed for the Abyssinian expedition, I find that it gives 90,000 tons more, or about one-third more tonnage for the Abyssinian expedition than was actually employed, so that my figures may be taken as a considerable over-estimate of the transports that would be required by an invader. My estimate is 50,000 men, at 1,000 per ship in 50 ships of 2,000 tons each, making 100,000 tons. I take (with all due deference to the learned lecturer) Colonel's Chesney's opinion that 5,000 horses are quite sufficient for the invasion of England, and on this ground that it would be as unwise to take coals to Newcastle as to bring a large number of horses to a country like England, where there are plenty of open towns from which the enemy could help himself. That is a condition which ought to be kept in view when drawing lessons from the Abyssinian expedition, for our country could also feed the invading force. 5,000 horses at 300 per ship, a number which singularly enough agrees tolerably well with the estimate given authoritatively by the learned lecturer to-night, will take 17 ships or 34,000 tons; 50 batteries with stores, &c., 10 per ship, will take 5 ships, or 10,000 tons; and if we allow for provisions, stores, and non-combatants 30 ships of 1,000 tons each, 30,000 tons, that will make as an outside estimate a total of 102 ships of 174,000 tons. Now, comparing that with the Abyssinian expedition, I find from the figures given by the learned gentleman that the transports employed were 302,000 tons. On the basis I have adopted in providing transports for an invading force it would have been this: 14,000 combatants, 14 ships, equal to 28,000 tons; 50,000 non-combatants, 1,000 per ship, 50 ships, or 100,000 tons; 35,000 animals, 300 per ship, 117 ships, or 234,000 tons; provisions and stores 30 ships of 30,000 tons, making a total of 211 ships, or 392,000 tons, whilst there were actually employed only 302,000 tons, leaving a surplus of 90,000, or about one-third more tonnage than was used. I found by inquiring at the Board of Trade that the number of voyages made by German, Dutch, Belgian, and French

* Reference to a letter in the "Times."—Ed.

steam vessels from various countries to London alone amounted in 1871 to 486 ships. Allowing that each ship entered the port of London four times in the course of the year, that makes 122 foreign steam ships trading with the port of London alone, or fully 20 ships more than is necessary to carry the expeditionary force referred to across the sea. Going, then, to another return of the Board of Trade, I found that the steam tonnage belonging to the Hanse Towns which entered the ports of the United Kingdom alone in 1869, three years ago, was 737,112 tons, being four times the quantity of tonnage required to convey the expeditionary force. But the Hanse Towns trade with other countries besides England, and the tonnage so employed is no doubt very great. That was in 1869. Since then three years have elapsed, and Captain Selwyn has put before you a long list of magnificent German steam ships belonging to only two companies, the great majority of which ships have been built since 1869, and we may suppose that many other steam ships have been added other than those given by Captain Selwyn. It would certainly be within the mark to credit the Hanse Towns with 1,000,000 tons of steam ships, or six times the required amount. A Parliamentary return shows that the amount of steam tonnage entered and cleared in the United Kingdom in 1869 from the United States was very small, owing to the destructively high tariff maintained in that country, but that from France, Holland, Norway, the Hanse Towns, and other countries amounted to 1,857,089 tons, or more than ten times the steam tonnage required by the invader. Now in the reply which Mr. Vernon Harcourt gave on the last occasion he said, "I will venture to say that the collective mercantile marine of Europe "does not equal the number of vessels actually employed in the transport of that (Abyssinian) expedition, *i.e.*, 302,000 tons. I am not aware what the collective marine of Europe amounts to, but here is that of one or two countries: France, 1,388,548 tons.

Mr. Vernon Harcourt: If you will allow me to explain, I do not mean that those figures include the coasting trade, of course I mean ocean-going ships.

Commander Dawson: Invasion is not ocean-going work. It is coasting work, across the North Sea and English Channel. Take another small state. In Norway I find that the aggregate mercantile marine amounts to 1,200,437 tons. In Holland it is 588,196 tons. I wont go into the figures before me as to the few other states, for they all happen to refer to small states, and unfortunately I have not an estimate of the aggregate tonnage of North Germany, which would have been very interesting. Another point which must be taken into consideration is, that if the foe had the command of the seas he would help himself out of our ports; why should he not help himself out of our ports, and lay an embargo on English ships in his own ports?

Then question 4. "Is it possible to be taken by surprise?" I think it is quite possible to be taken by surprise if you are disarmed; and the logical inference to be drawn from the paper is that we ought to disband the whole Army. In that case, if we have no fleet, it would be possible to be taken by surprise. I do not mean to say it would be possible to wake up to-morrow morning and find 50,000 men landed on the beach; but an invasion might be organised beforehand; for instance, to invert the order of transport, our Board of Trade and War Office might, without anybody outside being aware of it, so organise transport that, supposing we had an organized army with a regular staff and proper central system and so on, which is a supposition we must take into consideration,—supposing we had that sort of thing, then arrangements might be secretly organised for sending 50,000 men to London or Liverpool and embarking them with provisions, &c., in, say seven days, with the dock accommodation we have got; and I suppose that they have dock accommodation across the water wherever they have those large steamers at Hamburg, and so on. I take the time for collecting the ships from the different ports after embarkation, for they would not all embark at the same port, and for sailing 300 miles as four days. With the aid of electric telegraphs it can be done in that time without any difficulty, using steam ships only. The time of disembarking in harbour, because I do not see the necessity of disembarking on the open coast, might be three days, which would give us fourteen days. Now I call fourteen days a surprise if you are disarmed.

The next question to which I would refer is Question 5:—"What are the con-"ditions necessary to the disembarkation of an army in the presence of an opposing

"force by sea and land, assuming the latter forces to be inferior in numbers?" Disembarking an army in the presence of a hostile force is a nautical evolution which it is the province of an Admiral to conduct, and it is a very common nautical evolution, and one which any Admiral who is worth his salt would conduct easily. It hardly wants explaining. Soldiers have been landed frequently in the presence of hostile forces, not only in olden times, but as recently as the very last civil war in America. Those who have studied that war know perfectly well that at Port Fisher Admiral Porter landed a considerable body of men in the presence of a hostile force, whilst occupying their attention with his ships. I suppose a few 35-ton guns (if they are not rifled on an unmechanical principle, warranted to burst their shell prematurely, and sink their own boats, and kill or drown their own men) would not only clear the beach but clear a good way inland. At any rate that is a nautical evolution which has constantly been performed in war, and, if the guns will stand fire and the shell won't break up at the wrong time, can be done again.

Question 6. "Have the recent changes in the nature of armaments, as, for "instance, the introduction of steam, guns of precision, armour-plating, and tor- "pedoes, increased or diminished the relative defensive power of England?" Now I think there is a great deal of exaggeration in the statements made about torpedoes. Defensive torpedoes have been, up to the present, untried in tidal waters and in wide open spaces. We have no experience with them under such conditions, and so long as they are all stored up in Woolwich we never shall have any experience of them. We must not build, therefore, upon a weapon of which nothing is known. I have no doubt, having studied this matter many years, that defensive torpedoes may become a very useful auxiliary, but they are not a substitute for any other weapon. Moreover, the torpedoes are not in position, nor have we enough to put in position. If an alarm were given to-morrow, we should probably apply what torpedoes we had in store for the defence of such naval ports as Portsmouth, Plymouth, Pembroke, the Thames, the Medway, and so on; but we could not possibly provide torpedoes to defend all the mercantile ports where an enemy might naturally attempt to land; and therefore I think we should lean upon a rotten reed if we think we shall have torpedoes exactly in the right position at the right time, so that an enemy cannot land anywhere. Offensive torpedoes represent a very considerable addition to naval force, but unfortunately they help to raise the weaker naval power up to the level of the stronger. That was the opinion of Lord St. Vincent seventy years ago, and I believe that is the opinion of those who have studied naval "torpedo-warfare" since. If you could banish offensive torpedoes from naval warfare altogether, offensive force would be measured by ironclads alone, and we should be relatively stronger than at present. At the present moment there is not a single offensive torpedo on the British Fleet, and there are very few naval Officers who have had the opportunity of gaining any experience whatever of the tactics to be employed in "offensive torpedo-warfare." At this present moment the instruction given in the "Excellent" and the "Cambridge" in electricity, almost raises the presumption that naval men are to quit their ships and to become Royal Engineers to defend our ports, for they are learning military submarine mining instead of naval torpedoing. An Officer of the Royal Engineers writes, "I have been recently six weeks in the United States, "and found that three special torpedo vessels were commenced, whose speed it is "hoped will attain 17 knots per hour; that ten powerful steam-tugs were fitted "with telescopic outrigger torpedoes, to be worked from the interior; that the "monitors, about 30 in all, were fitted with boom torpedoes; that every vessel, "whether corvette, frigate, or gunboat, in the United States' Navy carried a number "of outrigger and towing torpedoes, to be worked from the vessel itself; and that the "Officers of the Navy were being thoroughly instructed, in classes of twenty at a time, "in the art of practical torpedoing, the course of instruction lasting several months."

The United States' squadron in the Mediterranean are even now gaining experience in the use of offensive torpedoes, and they are not the only foreign navy that is doing so. The only considerable navy in the world which is not gaining experience and acquiring dexterity in handling ships, so as to apply torpedoes effectively, is the British Navy.

The next point I would venture to go into is, have "guns of precision" improved matters? We are building ironclads like the "Monarch," the "Devastation," and

the "Glatton," which are, or will be, armed with 25- and 35-ton guns, rifled on a most unmechanical system, which have never been tested for continuous firing. They are, therefore, untried weapons; they have not been tested in the usual way in which all naval guns have heretofore been tested, by a continuous rapid firing, and in which they will be tested in the day of battle. I have heard eminent artillery Officers say that it is a very wonderful thing that these guns stand a sea voyage in time of peace without bursting explosively, and that it is a matter for congratulation that they are only slightly injured, or, at the worst, temporarily disabled, by firing a few rounds for exercise at a target once a quarter. Meanwhile their projectiles break up prematurely in the bore, to the danger of friendly vessels. If you want to organize the Fleet for defeat, you must do it from within, and one of the ways of doing so from within is to provide them with guns of precision rifled on an unmechanical principle, so that the projectiles cannot escape from the gun without damaging the bore or disabling the gun—guns which have never been tried with quick firing, and which their advocates think are wonderful in that they can stand firing eight rounds every quarter at slow firing, and only require to be carefully examined after 250 such cool and quiet discharges, and which we are afraid to heat by discharging even 100 rounds of continuous firing on the same day, lest the extra and more rapid consumption of powder should lead to untoward results. (Question.) A question has been raised with reference to Point 6, and I venture to answer that question. I wish to show how the British Fleet may be organized for defeat from within by supplying it with bad tools. Unless the invader can thrash the British Fleet so as to get it well out of the way and obtain command of the seas, he cannot possibly invade this country. That is all; and I will not intrude further upon your patience.

Captain HOSEASON, R.N.: In addressing you, Gentlemen, let me first take the opportunity of thanking the Council for inviting Mr. Harcourt to raise so important a question. The second thing I have to observe is, how deeply we are indebted to Mr. Harcourt for bringing this subject before the country. There are perhaps few civilians in England who could have treated the subject with as much ability as he has done, and although I entirely demur to nearly every statement he has made, yet at the same time I am under deep obligations to him, and I am sure the country ought to be, for raising so important a question. The first night on hearing his paper read I determined not to rise, wishing to have the advantage of reading the lecture submitted to our consideration. It is, however, not a lecture properly speaking, but a brief, and a most elaborate brief also, when we consider the series of questions so categorically put. We must, moreover, not forget that Mr. Harcourt has not been satisfied to submit the subject to us in this form, but has subsequently, whilst we had the paper under consideration, published still longer articles in the *Times*. It is true that we, the Members of the Institution, in reply, cannot travel out of the record, but must confine ourselves to the paper placed in our hands as printed by the Institution. I shall therefore not attempt to deal with the question as a whole, seeing that each Member is usually limited to ten minutes in his reply, all I shall seek to do is to throw the current of your thoughts into the proper channel, and direct your attention to the size and capacity of the steamers as constructed in the present day, as will be seen by the tabulated data I have placed upon the wall.* Mr. Harcourt has suggested a most important question for this Institution to answer, viz., that of the "conduit pipe." He has asked us, if there are a million of men over there, how that million of men can be brought over here, and he says truly that it is useless to talk of the number of men there are in foreign armies, without there are facilities for transporting them to this country. This is putting the question in a very fair way, and Captain Selwyn has replied to it most conclusively as far as Germany is concerned. But it is when Mr. Harcourt dwells on the difficulties of sea transport, and when reasoning by analogy he cites the Crimea, and Abyssinian expeditions, that I differ most materially with him; there is no analogy whatever between moving armies in such comparatively sterile countries as the Crimea and Abyssinia, and moving them in such a wonderfully fertile country as England; there is also no comparison

* For particulars on this and the following points, see Appendix at the end of discussion.

between the difficulties of supplying an army from a single sea-base alone, caused by the general sterility of a country, and gathering a large portion of the supplies from a centre of a circle in a fertile one. A march of only 10 miles from a beach will bring an army to the centre of a circle whose area is 400 square miles, for the areas of circles are as the squares of their diameters, that is to say, a circle of 20 miles diameter has 400 miles area; consequently detachments despatched from a cavalry regiment placed in the centre of such a circle, marching only 10 miles out from a camp and 10 miles home, would have at its mercy the produce of 400 miles area of this fertile country. It is thus that the German cavalry so materially served to furnish supplies to its army in France. On the other hand in Abyssinia, where even grass and hay were not to be found within 80 miles of the beach, the mule or horse consumed in 10 days the 200 lbs. of fodder it was capable of carrying on its back, thus rendering invasion nearly impossible without the populace as allies, for an animal daily consumes, in round numbers, nearly ten times the weight of food that will support a man and keep him in good condition. The economy in the use of carts, wherever the country will admit of it, is very evident, as is shown by the tables I have placed upon the wall; nothing is therefore more important than having an ample supply of such means of transport to an army taking the field, and in due proportion to its anticipated wants; it being simple madness to rely on the ordinary resources of any country, however fertile or however rich. The moment an army is disembarked in an enemy's country, that moment it ought to be able to advance and seize upon an advantageous position. The English transports in the Crimean expedition Mr. Harcourt stated were 400 vessels. I pointed out to him at the time that he had included the fleet of our allies, he replied he had not done so, or "Certainly not." Now the document I produce on Admiral Sir William Mends' authority gives only 120 ships for the English instead of 400 (see Appendix).

Mr. Harcourt: If you look at Sir William Mends' paper, read before the Institution, he says that the vessels were 400.

Captain Hoseason: 400 including the Allies, but not 400, as your document says, for the English Army alone.

Mr. Harcourt: I read the figures to-night.

Captain Hoseason: The fact is, that instead of going, even in those imperfect days of transport, with 400 vessels, we, the English, had only 120; and if you observe the list, you will find that half of these ships were sailing vessels. Mr. Harcourt called our attention to the fact that the length of the transit to the Crimea from Varna was only about 300 miles, although it took eight days to accomplish; and why? because every ship was tied to the speed of the slowest, and, as you will observe from the data I have supplied of the ten ships of the line, only two had screws, and there were 64 transports mere sailing vessels. Mr. Harcourt in his paper further says, that it was very calm weather; and so it was, beautiful weather no doubt for steamers, but very bad for sailing vessels, and the consequence was that they took eight days to perform a voyage which in the present day, and with such vessels as Captain Selwyn shows us the Germans have, would not occupy more than thirty hours. Now, the question of a successful invasion turns upon this point. There is no possible doubt of our faculty to move any amount of men, say 150,000 or 200,000, the only difficulty is to disembark them quickly on an enemy's coast. It is here demonstrated that there is no difficulty in moving the men, horses, and stores. Since this debate commenced, a Steam Company's agent has been summoned before the Lord Mayor for having exceeded the number of persons that ought to be put on board the London steamers running from London Bridge to Richmond. These vessels were only authorised to carry 470 passengers, and they took 530 each; and on that one day, that particular Company—only a fraction of the river boat navigation—took 80,000 people, and moved them 16½ miles to Richmond. Any German expedition coming to this country would be provided not merely with these immense ocean boats, which Captain Selwyn has referred to, but also with smaller boats for landing the troops,* and then there would be no possible doubt of their ability to land any amount of men rapidly if they were only once brought over here.

* The able tactician of the German armies, as we have the past to prove, does not trouble himself to advertise during war for the resources he needs, he simply seizes

Captain TYLER: Mr. Chairman,—I feel equally grateful with the last speaker to Mr. Harcourt, who has been so good as to bring this subject before us, and I demur as much as the last speaker to the various statements Mr. Harcourt has put forward; but I differ from the last speaker as to the point of view from which we should consider the question before us. There is no doubt that the importance of this subject cannot be exaggerated; and to the various points which Mr. Harcourt has raised, clear and precise answers should be given; and not only so, but the inferences which Mr. Harcourt has drawn from the premises which he has laid down, require to be very carefully considered, and, if we are able, confuted. The errors of detail into which the hon. gentleman has fallen have already been partially established; but the errors of his general arguments have hitherto received scant attention; and to this point I propose in a very few words to address myself. Mr. Harcourt, in discussing this great question, attempts, in the first place, to tie us down to one part of it. He says, in his paper, "*The question to which I would ask "your attention is the question of the defence of this Empire, and that question alone. "That is the question which necessarily occupies, and has very much agitated public "attention—that is, the question of the invasion of this country, in which I also include "its colonies and its other dependencies.*" But the hon. and learned gentleman forgets what a man of his erudition must be well aware of, that in certain cases the true mode of defence is a judicious assumption of offensive operations. To take one example, the defence of Canada. It has often been urged that in the event of serious attack by the United States, Canada would be indefensible; and I have much regretted to hear such language from gentlemen, and even Officers of Government, high in authority both in Canada and in England. Remaining on the defensive to prevent invasion of Canada, with its long frontier and scattered population, by large or small forces at distant points, would, no doubt, be an impossibility. But there is another means of defending Canada, and a means which we must be prepared to adopt as long as Canada belongs to, and is an integral portion of the British Empire. That means, I need hardly say in this Institution, is by attack in sufficient force and with sufficient rapidity upon certain important ports and seaboard cities of the United States. If we are to maintain the honour and safety of the British Empire in America, we must be prepared to successfully invade, and to dictate terms of peace on American ground. It is neither necessary nor desirable to indicate here what the precise points of attack should be. It is sufficient for the argument before us to contend that a portion, and a considerable portion, of the land forces and of the naval forces at our disposal would be devoted necessarily to that object, and that, supposing we were at the same time engaged in war in Europe, a very large deduction from our available forces must be made on that account. But Mr. Harcourt also says, "*We have heard it said that we should always be prepared for "all emergencies. Now, I propose that we should deal with this combination of cir"cumstances—that we should have war made upon us at once by France, Russia, "Prussia, and the United States. If you can conceive all these countries combined, "you will find that after putting ship for ship against theirs, it would leave ten iron"clads of the first order to spare as against them.*" Well, Sir, to this might be added trouble in India; and even if we are to be at war with only one or two of these Powers at a time, what I have said in regard to America applies also, although in different degrees, to other nations. If we are to sit still, as contemplated in Mr. Harcourt's argument, and to content ourselves with preserving this island from the risk of invasion, any wars in which we may be engaged will be long ones. It is difficult, indeed, to see how they would be brought to a termination. They would be destructive to us by their very duration; and these are no idle speculations. Wars have not yet ceased in the world. The visions of the greatest, the most

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them from his own countrymen, as well as from everybody else, and in the event of an invasion of this country, the Rhine and the ports of Germany would furnish all the small steamers he would require: if successful, a bill on the Chancellor of the Exchequer, to be paid in hard cash at the expiration of the war, as is now taking place in France, would be the way he would liquidate the debt with his fellow-countrymen. I need hardly point out how this mode of transacting business simplifies the art of carrying on war on a grand scale.—J. C. H.

rapid, the most momentous operations of war that are recorded in the history of the world have hardly yet faded from before our eyes. No one can predict that our turn may not come next, and that at no distant period; and if we are to maintain the honour and safety of our Empire—which is surely worth maintaining—we must be prepared to prosecute offensive as well as defensive operations in various parts of the globe.

Looking at the matter from this point of view, the argument which is at the base of Mr. Harcourt's inferences, entirely fails. It is not because we have a preponderance of ironclad ships, and are therefore safe at this moment from invasion in Great Britain, that we are properly prepared to defend our Empire and our commerce in all parts of the world. It is not because the French and the Germans have not, or could not purchase enough ocean going steamers between them—even if it were true, which it is not—to act as transports to carry 30,000 or 50,000 men, with cavalry and artillery, across the channel, that our Empire is safe. It is not because we could, if necessary, add to our fleet, that our honour is beyond insult, or our safety assured. Those results can only be obtained by preparation for rapid and decisive offensive blows, by combined land and sea forces, at the proper moment, in Europe or in America, if and when the hour of need shall arrive; and our Army is certainly not in excess of our needs for such operations, and for securing ourselves at the same time from all risk of invasion.

Another argument which has evidently been in the mind of the learned gentleman, and which is too often employed, is that as we cannot have an army commensurate in size to the armies of the Continent, we should not have an army at all with a view to offensive operations. But, Sir, our relative position as regards numbers, with reference to the armies of Europe, has been pretty much the same at all periods of time as it is at present. We have, at different times, sent small forces to the Continent of Europe, and with some success. We *have* heard of the victories of Marlborough, and of some little achievements on the part of Wellington and his forces in Spain and Belgium. As far as I remember, the battle of Blenheim was won mainly by the presence of 13,000, and the victory of Waterloo by not much more than 30,000 British bayonets.

Then, Sir, to answer the real question in Mr. Harcourt's paper, "Why is our Army twice as large as it formerly used to be?" Why have we now 100,000 men when we used to have 50,000? I am not quite sure that the numbers are correct, because I find that we could not bring 50,000 bayonets into the field at this moment if we wished to do it; but even taking them for granted, the most conclusive answers may be given to this question—first, because preparation in peace is more necessary now than at any former period for successful war. Secondly, because rifled guns, breech-loading muskets, railways, and telegraphs combine to make the operations of war far more rapid than they were at previous stages of our history. A country may now be conquered in as many months as it took years to conquer it formerly; and in the case of our own country, it is a question rather of days than of months if sufficient invading force were once to land on our shores. And, thirdly, because we have by offensive, combined with defensive operations, to maintain and protect, under the above circumstances, an Empire on which the sun never sets.

Not only, then, must we be prepared, if engaged in deadly strife at the same time in Europe and in America, merely to resist invasion, but we must also be prepared to assume the offensive in both hemispheres. Our fleets will further be required, not only to protect our colonies in all parts of the land, but also to protect our commerce on all the seas. I do not want to occupy your time by referring to the different parts of the world in which our ships are found and to which our commerce is carried; but I would ask you to remember them all in considering this question; and to think that it would be our duty, not, as the Americans did, to allow vessels like the "Alabama" to destroy their commerce during their civil war, but to fit out and to keep ships of war in all the seas of the world, which should prevent such destruction to our commerce; and, while we are doing all this, we must at the same time be undeniably safe against invasion from, say, two European Powers.

The British Empire contains one-fourth of the population of the globe. The mere protection of this island from invasion, though put forward by Mr. Harcourt

as almost the only object, is only a very small item compared with the real necessities for our armaments. We must be prepared to maintain, offensively and defensively, the ships, the colonies, and the commerce for which Napoleon sighed in vain, but which it is our duty and interest to protect, alike from those enemies abroad, who would wrest them from us, and from those enemies at home, who would, if they could, starve our armaments, throw off our colonies, destroy our wealth, and dissolve our Empire. By God's help, we will vanquish both, and work out the glorious career that lies, if we are true to ourselves, before us.*

Captain SELWYN: I have recently passed through the United States, and lived with them, and tasted their hospitality; I should be very sorry indeed that it should ever go forth from this Institution that we should look upon them as anything else than temporarily alienated from us even in their worst moods, for I do not believe there is ever a chance but that the United States will hold out its hand to us the instant we are in any difficulty.

The CHAIRMAN: I do not think it was at all intended; it was simply an illustration of a principle.

Colonel ALCOCK: I should wish in a very modest way to be allowed to support the opinion just given by Captain Tyler, which is that the question which has been brought before us and which is now being argued does not comprise the whole subject. The question which is now before us, gentlemen, is the absolute force of States, that is, the absolute, the positive, the actual force which would be immediately available at any time and upon any emergency. Now it was seen by one of the speakers upon the last occasion that this does not include the whole question. I recollect perfectly well his having said, "But the learned gentleman has made no provision for the "unforeseen, the ordinary unforeseen." Gentlemen, that word "unforeseen" represents the relative power of Nations, which is quite a different thing from the abso-

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* The following extract from a report on the "Dangers and Defences of New York," by Major T. G. Barnard, U. S. Engineers, and published in New York by D. Van Nostrand, 1859, is interesting, as bearing on this subject:—

"The recent war of England and France against Russia may illustrate my meaning; for it has taught us what to expect were either of these nations to wage war against the United States.

"No invasion of territory, no attempt at territorial conquest was made or thought of; for it was well foreseen that no decisive results would flow from such means. The war consisted exclusively in attacks on maritime places—great seaports—seats of commercial and naval power. Such places, by their vast importance to the wellbeing and prosperity of a nation, by the large populations and immense amount of wealth concentrated in them, and by their exposure to maritime attack, offer themselves at once as points at which the most decisive results may be produced. Cronstadt, Sebastopol, Sweaborg, Kinburn, Odessa, Kertch, Petropauloski, and other places of less note, were in succession or simultaneously objects of attack, while such as the first named became indeed the true seats of war.

"Around Sebastopol assailed and assailant gathered their resources, and on the result of the arduous struggle may be said to have turned the issue of the war. Had it not been so decided *there*, Cronstadt would have been the next field of combat, for which indeed the Allies had made the most enormous preparations.

"Is it not *certain* that in future all war of maritime Powers against the United States will take a similar course? All territorial invasion being out of the question, it is against our *great* seaports and strategic points of coast defence, such as New York, New Orleans, and San Francisco—pre-eminently New York—that an enemy will concentrate his efforts. Against these he will prepare such immense armaments,—against these he will call into existence special agencies of attack, which (unless met by an inexpugnable defensive system) shall *insure* success.

"The mere defence of the city against *ordinary fleets* is no longer the question; but *through the defensive works to be here erected the nation is to measure its strength against the most lavish use of the resources of a great maritime Power, aided by all that modern science and mechanical ingenuity in creating or inventing means of attack can bring against them; in short, in fortifying New York, we are really preparing the battle field on which the issue of future momentous contests is to be decided.*"

lute force of States. When a war begins, the absolute force of States is brought into contact, and in the progress of the war the relative power of the contending nations is gradually developed. I say that to compute and estimate the sources of that Power is one of the most difficult questions which any military or naval man can have, or ever has, attempted to accomplish or decide. Mons. Baillet gave his attention to this subject, and after having studied it for twenty years he published his work in 1868. He, in the most exhaustive manner, took in every condition which is included under the head of the relative power of nations, and at the conclusion of his work he tabulated the whole, bringing out the absolute force and the relative power of every nation. He there shows that the absolute force and the relative power of France was superior to that of Prussia. His work was published in 1868, after twenty years study of the subject. The Franco-Prussian war afterwards took place, and it must be palpable to everybody how wrong his conclusions were. He likewise puts England the first both in absolute force and relative force, and I believe that in the latter he is also wrong, as we shall be if we over-estimate our relative power; a point to which it appears to me that Captain Tyler has directed your attention. It is a clear mathematical fact that in the proportion in which the absolute force has to be called away into distant operations, the relative power must decline. Mons. Baillet was of course carried away by national vanity and the recollection of previous achievements, just as Captain Tyler has referred to our own at Blenheim and Waterloo. Mons. Baillet was led away by that, and likewise led into another mistake; he did not calculate that a nation with an imperfect commissariat was not quite certain of carrying a war into the enemy's country which would have compensated for that deficiency, and I say that we, carried away by our national vanity, our over-confidence, or blinded by the achievements to which Captain Tyler has referred, we may be destined to exemplify exactly the converse of what happened to the French—they calculated upon carrying the war into their opponents' country, and we assume that there is no nation on the face of the earth which, under any possible condition, can bring the war into our own; it is clearly our national duty to make it impossible, but that has not been done; and I say, gentlemen, that this is a cause for much consideration, and I will even allow myself to use the word "alarm." It is usual to say that we are no alarmists. Well, I say that I am an alarmist; but I take the word "alarm" according to its proper meaning, which is "*all' armi.*" We must not confound alarm with panic. "Panic" is an old word, which means a sudden, unaccountable, and contagious fear. Alarm is derived from *all' armi*, "*Aux armes!*" "Alarm," means the act of calling all good citizens to be prepared for the defence of their constitution or their country, and is one which will prevent the great calamity of a panic if any unexpected and sudden necessity should arise. Allow me to add one word: if ever we agree that the difficult and critical subject of the relative power of nations should be discussed, it would be discussed more ably in this room than in any other place, for there are men here who can understand it, and it is of more importance to this country than to any other empire in the world.

Lieut.-Colonel CHESNEY: I wish to ask a question which may help to reconcile a difference of fact between Mr. Harcourt and Captain Tyler. Mr. Harcourt has given us some numbers to-night from a return of troops in England. I hold a return of the actual state of the troops as they were *in England* strictly on the 1st of May, which is strikingly different and in every part is under his, I would ask whether Mr. Harcourt's figures do not include Scotland and Ireland?

Mr. VERNON HARCOURT: I said the United Kingdom.

Captain HOME, R.E.: In his lecture, Mr. Harcourt told us he was a lawyer, and accustomed to elicit truth by the examination of friendly, and the cross-examination of hostile, witnesses.

Facts are, of course, the great things to be sought in dealing with such a question as that before us, but facts coming from a legal mind do not, I think, bear the same face as when they come from a judicial mind. Captain Hoseason has termed Mr. Harcourt's lecture a "brief," and a great judge has drawn attention to the fact that a legal mind seeks the triumph of the cause it espouses, a judicial mind seeks the triumph of truth. Now I think Mr. Harcourt has so examined his witnesses as (quite unintentionally, I am sure) to seek the former, not the latter. An example of

this is the number of horses which are to be brought over. He supposes an enemy to come with a force of 50,000 men and 25,000 horses. The German Army invaded France, where there was no sea to cross, and where there was a country well adapted for cavalry, with one horse to six men. Now I think it should be shown why an army coming across the sea to a country ill adapted for cavalry, should come with three times the number of horses that the Prussians thought necessary to take to France. The next point was the Abyssinian expedition. We have heard something about the Abyssinian expedition to-night, but I really think it is almost worthless to go into the number of vessels and the quantity of coals, because there is as much similarity between the invasion of Abyssinia and England as there is between a naked Abyssinian and a clothed Englishman. The next thing was the Crimean expedition. I must say I fully expected Mr. Harcourt would tell us, after he had described the number of months the expedition was preparing, the number of days it took to embark, and the time it took to cross, and the time to disembark, I fully expected him to say that it was met on the beach, driven back, and defeated. But, Sir, the Crimean expedition was one of the greatest successes in the world. There we had two nations, thousands of miles away from their own country; they were an immense time organising the expedition; they took an immense time to cross, using sailing vessels; and when they got there they were met by three cossacks and a Staff Officer, who looked at them. They landed quite comfortably, waited on the beach, cooked their dinners comfortably, and made themselves happy; and then went and attacked the Russian Army that was in position, two days afterwards, and defeated it. That was a witness decidedly in favour of an invasion being possible, and not a witness against an invasion being possible. There was one witness, however, that Mr. Harcourt did not produce, and that was the expedition to Walcheren. That expedition was a very peculiar one in many ways. On the 19th of June orders were given to prepare for that expedition—I take this from the Parliamentary papers—and they sailed on the 28th of July. They carried 41,000 men of all arms. They landed on the 30th of July, captured Flushing, and might have taken Antwerp. And why might it have done these things? Simply, Sir, because the English had at that time the command of the sea, and because the French Army were engaged in the campaign of Wagram, on the Danube. There were very few troops at that part of France, as they were engaged elsewhere. That shows how easily such expeditions may be organised and carried out.

Mr. Harcourt has put certain questions, to which he wishes answers to be given, and, amongst the rest, he asks, "What are the character and extent of the preparations "necessary in order to such an enterprise as the invasion by sea of a country possessed "of a powerful fleet?" Well, Sir, I am perfectly free to acknowledge that if a fleet is present, and ready to dispute the passage, I do not think a passage could be forced, except by a very much more powerful fleet than that which attempts to defend it. But the question is, will the fleet be there? Now, Mr. Harcourt went through the ironclads; he told them off, one by one, to each other; and this one was to take that one, and, he said, "Here are ten left." But I argue that that is not war. The Emperor Alexander of Russia appears, before the battle of Austerlitz, to have reasoned precisely as Mr. Harcourt has done. He was a young man entering life, and, amongst other things, he is represented as being very ignorant of war. He appears to have gone into the question, and to have said, "Here is a Russian soldier; he carries so many rounds of ammunition and a "firelock; he is clothed the same as a French soldier; we put that Russian "against that Frenchman, and there is another, and so on," and as he told them off, the Austro-Russian Army, he says, "Here are 20,000 men left." After Austerlitz, what was the result? When the French General Savary went to see the Emperor Alexander, he said, "How was it whenever we met you you were three "to one, although you were over 20,000 inferior to us?" The reason of this was that the Emperor Napoleon, who commanded the French Army, had not the same idea of war that Mr. Harcourt has. Mr. Harcourt's idea of war is, that war is the art of being strongest: but Napoleon says *war is the art of being strongest at a given point, and that point the decisive one;* and unless Mr. Harcourt can make sure that he always will have his spare ironclads upon the decisive point whenever they are wanted, I think his argument falls to the ground.

There was a remark made by a gentleman on "the unforeseen." Mr. Harcourt referred to that, and said he really could not provide for what was "unforeseen." Well, now, I do not dispute with Mr. Harcourt for the meaning of the word "unforeseen," I think that is open to discussion; but I should like to remind the meeting of the words of a statesman in England who for many years has filled a considerable place in the minds of his countrymen. Mr. Disraeli, the master of happy phrases, says that there is nothing so possible, no, nothing so probable, as the unforeseen; and I think that is rather against Mr. Harcourt's idea. Take the case of one of our great races. Who wins, the foreseen horse of the papers, or the unforeseen horse? Generally it is the outsider, the unforeseen horse. Mr. Harcourt has really put himself in the position of laying tremendous odds on the favourite against the field.

Only one other point, as to an expedition made in the presence of a blockading fleet. In the year 1798, when the English Navy was certainly as much in command of the sea as it at present is, when the Fleet was commanded by Nelson and St. Vincent, there was an expedition from Toulon to Egypt. That expedition sailed on the 19th of May; it took 13 sail of the line and 400 transports, with 36,000 soldiers on board. Three English sail of the line and 4 frigates were despatched to observe it, but failed to fall in with it. On the 12th of June the French captured Malta; and on the 1st of July they landed in Egypt. On the 1st of August the battle of the Nile was fought. It is a very remarkable circumstance that Nelson, in hunting that fleet, actually crossed its track, went within 15 miles of it, and yet missed it, showing how easy it is for great expeditions to put to sea, even when blockaded.

Captain WHEATLEY: It will shorten the discussion very much if the question of transport is considered as decided already. There has been proof enough that it can be done.

The CHAIRMAN: I think the suggestion just now made is that we have heard quite enough about transport.

Captain WHEATLEY: Does Mr. Harcourt give in on that point?

Colonel OUVRY: If we look at these two slates, on which are given merely part of the vessels which would be forthcoming for the purpose of transporting an invading force, I think that the question is really decided as to whether an enemy could produce sufficient shipping to land a large body of men, even as many as 200,000, on this coast. I have not the slightest doubt of that. But I do not consider that that is the question. I think that the Navy, the Channel, as well as any other natural or artificial means of defence ought to be entirely ignored in looking at this question. I recollect an old song which probably may be known to many naval men here. I forget how it commences, but there are two lines in it with regard to invasion—

> "And should their flat bottoms in darkness come o'er,
> Still Britons they'd find for to meet them on shore."

Now, there I say lies the whole question. Have we Britons to meet them on shore? I say emphatically we have not. If the enemy had 200,000 men, or say more, if they had 500,000 on these shores, I say that we have not got men to meet them; therefore, in mooting the question of invasion, the fact that we have a navy ought to be totally ignored, that is, if England wishes to hold her place among the nations of Europe. It is not a question of our maintaining an army of 50,000 or 100,000 men, but it is a question whether we, as a nation, are in a position to meet other nations on equal terms according to the new state of things. I hold that the greatness of England is in the most precarious condition under the present system of a comparatively infinitessimally small army and reliance on her navy. There is only one means of meeting the case. It is not ironclads, and it is not torpedoes, but it is the acknowledgment of the necessity for general service; and if Englishmen cannot be persuaded to do this, their manifest duty, then they will have to take the consequences. Thus I agree with the learned gentleman, that if we look to that state of affairs, our Army is either infinitely too small, or it is doubly too large. I maintain that it is infinitely too small. I perfectly agree with Mr. Harcourt that you might just as well save half your fifteen millions, and have half the army you have got now, if all idea is aban-

doned of meeting an enemy in the field, and the policy of trusting to our "wooden," or rather, I should say, our "iron walls," is to be the one pursued.

Captain WHEATLEY, R.N.: I think we may take for granted that the possibility of transport has been sufficiently asserted. The next question is how to meet an enemy's fleet and expedition, I won't say from Prussia, but from any part of the world. Any expedition, under the present state of science and inventions, would scarcely attempt to leave the port without a swarm of fast sailing torpedo vessels—vessels, I should say, approaching the type of a broad-backed sword, held edge downwards. And such vessels would be required to guard our own convoys in the case of any future war. I dare say many people here will call to mind the exploit of Lieut. Cushing, of the United States' Navy, in the destruction of the "Albemarle." Let us take the "Thunderer," or the "Devastation," or any of our ships. These ships would have no terrors for such a man as Lieut. Cushing with fast sailing torpedo vessels, and I am bound to say we have dozens of men in our own service who in high-speed-torpedo vessels, would have no hesitation in running amuck amongst any fleet of an enemy's transports or men-of-war either. The only chance which a ship with guns has against a torpedo vessel is in being able to turn away from her and keep herself always at right angles to the torpedo's beam, so as to keep her constantly under fire, and by increasing her distance, so as to keep out of the sweep of the torpedo. I have alluded to the Harvey torpedo. Naval Officers are very insufficiently instructed in the use of these torpedoes at present, according to Captain Dawson's account; but we will take it for granted that in a short time they are quite as capable of manning these vessels as Captain Harvey himself, and he has been very successful. There is another sort of torpedo vessel (Question). The question is, I presume, how to stop an expedition from coming across. This very torpedo vessel, with its mysterious fish, by stationing herself—Captain Colomb has taught us to estimate the advantage of diminishing distances—this vessel, at a mile from the enemy's fleet, with its torpedo going seven knots an hour, suppose they are going three knots, her torpedoes will come in contact with the enemy's foremost vessel in six minutes. (The CHAIRMAN: Does not that rather partake of the unforeseen? May we not assume it would do that without a full description?) That is stated to be the case with the Whitehead torpedo. If the vessel is at an angle with the enemy's fleet, if the torpedo misses one vessel it must hit another, and that would cause a great deal of confusion and destruction.

Colonel BAKER, 10th Hussars: I am sure that we all regret very much to find that we are so thoroughly at variance with Mr. Harcourt. We must all feel a very great debt of gratitude to him for coming here into what he must have known would be a hot-bed of opposition (General GORDON: You speak for yourself); and I think Mr. Harcourt by this time will consider it is a hot-bed of opposition. I think that the error, if I may call it so, into which Mr. Harcourt has fallen has been this. He has come before us nominally to ask us questions relative to this important subject, but he has based these questions upon assumptions of his own; and if we can prove that those assumptions are incorrect, what is the value of the reasoning which is based upon them? I will not go into the question of transport, for the meeting has decided that this question shall not be entered into any more; but Mr. Harcourt has told us that he is not satisfied with the data which has been placed before him. (Mr. HARCOURT: Oh, yes, I am quite satisfied; the figures are most satisfactory.) I can assure Mr. Harcourt that I hold in my hand data, which I shall be very happy to give him, and which I think will alter the impression which he still holds relative to the power of the transports of foreign countries for carrying a sufficient army for the invasion of England. But the question of transport was not the only error into which Mr. Harcourt fell. He has given us certain data relative to the navies of foreign countries, and I think if you examine this table you will find that they are strangely incorrect. Mr. Harcourt, in his lecture, spoke at one time of three Prussian ironclads, but in his table he not only gives you the names of five Prussian ironclads, but he shows you five more building. When I refer to his table relative to the Russian Navy, I find an equal error; he has not reckoned the old vessels, which he has given us in his table, and he has not at all reckoned four others, which are described as building. When we turn to the French Navy we find also that he has not reckoned any that were described as

building. Now I have no doubt Mr. Harcourt has gone into these figures. Does he know how many we ourselves are building at the present moment? If he does, he knows it is very small. Then Mr. Harcourt put forward an assumption of the force and constitution of force by which we should be likely to be invaded, and I think by this time he must be aware that that is not the sort of force that any military power would employ for the invasion of this country. He also assumed the force which we should have to repel the invasion, and he has fallen into this error, an error which he has repeated to night, he has reckoned the whole troops in Great Britain and Ireland as available for opposing a landing in England alone. Mr. Harcourt has quoted a branch of the service with which I happen to be connected; he quoted it once before, and he has quoted it again to-night, and he has named 13,000 men as the cavalry force of this country. But I need not tell practical soldiers that cavalry are not very useful without horses, and the force of horses, as he has shown you to-night, in Great Britain and Ireland, is only a little over 7,000. We know that practically this represents a very much larger force than we are ever able to bring into the field. I will guarantee that at the present moment in England alone the cavalry could not bring 4,500 men into line-of-battle. I will give Mr. Harcourt the returns privately, if he likes. (Mr. HARCOURT: That, I think, is the number of horses given in England.) Then, again, he assumes the landing of a very large force of cavalry, whereas we know that cavalry would be really an embarrassment to an invading army rather than an assistance to it. If an enemy ever invaded England it would be with an army composed principally of infantry and artillery, and principally of infantry. Infantry can be embarked and landed with the greatest possible facility. I have spoken to one of the leading steam-ship owners of Liverpool, and I have asked him to give me a good commercial idea relative to what such vessels as we see marked down on the slates relative to what those vessels could actually carry, and he says that 3,000 men is far below the mark. We have had all sorts of data laid before us here, and data which are likely to lead us into most erroneous calculations. For instance, relative to an invasion of this country, the same data have been applied to the transport of troops for only 21 miles, as for 300 miles That is evidently erroneous. You can place a very large number of troops on board for short voyages, and I can assure Mr. Harcourt I heard on very good authority that a French two-decker in going to the Crimea actually had on board 3,700 men. I am quite sure that Captain Selwyn and those naval gentlemen who have spoken upon this subject will agree with me when I say those troops could most easily be disembarked on the shore of this country. It is quite evident at the same time that if these infantry were brought over, guns could be brought over without horses. I have taken the trouble to make a calculation as to the actual weight each ship would carry relative to artillery and to infantry. I find that, taking the standard of a North German corps as at present organised, with all its infantry, guns, and carriages for transport, with 3,000 infantry, there would only be carriages and guns of 240 tons in weight, including the whole of the ammunition; that is to say, if you divide the men of a North German Army corps into the proportion of 3,000 infantry to a vessel of 3,000 tons, her proportion of artillery, of transport carts, of food for one month, and ammunition, and the weight of the men themselves, will only come to 694½ tons. The same authority I referred to above informs me that a vessel of that class will carry 3,000 tons of cargo. Although we know that artillery is more or less bulky, we also know that guns can be dismounted and packed away in a very small space, and carts can also be dismounted and packed in a comparatively small space; therefore I think we have proof to demonstration that vessels such as we see described here would actually carry 3,000 men and food for those 3,000 men, with their proportionate artillery without horses, and their ammunition.

We have now to see whether they could effect their landing. Mr. Harcourt is of opinion that even if our Fleet were absent from any cause, and we may imagine such a cause,—God forbid it!—such as the blockade of the American ports or anything of that sort, if our Fleet were temporarily absent, he imagines that other vessels, the other mercantile vessels of this country could still be taken into service. But you cannot suppose that invasion would ever be attempted, unless the Power which attempted the invasion, had a preponderance of naval force, at all events upon our shore; that preponderance of naval force, if it existed, would evidently prevent our

mercantile marine from interfering with the disembarkation. But after assuming that they could gain a preponderance of naval force, we must look back I think to history to see what would be the chances of the success of an invasion. Now, if we look back to ancient history, we must remember that the very blood that we are so proud of, is really the result of three or four successful invasions of this country: Saxons, Danes, and Normans. Again, I believe if you go into the question you will find that there is no instance in modern military history of an unsuccessful invasion. Mr. Harcourt will correct me if I am in error, but I cannot remember a single instance of an unsuccessful invasion attempted in force. I think that is very important. Mr. Harcourt I believe holds the impression, and there may be some grounds of argument for it, that we should reduce our Army to a very small force and devote the expenditure to an increase of our Navy. But this is a subject which was considered very deeply in the time of Lord Palmerston; it was gone into very carefully, and the result of it was that it was believed that no dispositions could be made which would ensure our Fleet always being present at home; instead, therefore, of resting upon that supposition, we commenced the fortifications of Portsmouth and Dover. Since that time we have been engaged in the re-organisation of our Army; and although Mr. Harcourt may have some reason for arguing that if an invasion is possible at all, it may be possible to land a million of men as well as to land 240,000, or whatever the number may be, still you must remember that any nation attempting the invasion of this country, would balance the probabilities of the case. We and Mr. Harcourt have been at variance upon this one point. He assumes that invasion is improbable, and therefore we may effect reductions in our Army; we do not say that it is not improbable, we do not say that it is not difficult;—there are many operations in war which are exceedingly difficult, but which have to be attempted;—but what we do say is, that it is possible, and that therefore we ought to do everything in our power to make it so difficult that an enemy would not be likely to make it. Now, as I said before, it has been considered, and it was decided, that this could not be done by having a Navy alone without an Army. Since that time we have therefore devoted ourselves to our fortifications, and as you all know we have very recently devoted ourselves most seriously to the reorganisation of the Army, we have endeavoured to create a system which will, in years to come, give us very much larger reserves, and I think that Mr. Harcourt will see that although at present our Army may not be in a very formidable state, that when those reserves are created, when the Militia is more highly trained, and the Volunteers put upon a better footing, at all events it will be a very serious force for any foreign army to encounter after landing in this country; it would be a very serious force, because it is not probable, it is not in the least probable, that they will be able to land a million of men; taking the most favourable probabilities 200,000 or 250,000 will be about the maximum, unless our whole Fleet is entirely destroyed, and in that case I think that our present organisation would not prevent the invasion and conquest for a time of this country. But I will ask again, upon what principle are we to adopt this system of reduction? Is the country so poor that it cannot afford to insure its own safety? Economy is an excellent thing, but economy should be combined with efficiency; and if you reduce your establishment to such a degree that they are not effective in their several capacities, it must evidently be the very worst economy. I think Mr. Harcourt, since he came here, has changed his views very considerably upon certain points. I am quite sure that he does not hold the ideas which he held when he first put forward his views in this room in their entirety. A great many of his facts he will allow have been disproved. Here is one of his points about the relative mercantile marine of the North German States which I think it is really worth while to read to you. "If you examine the mercantile marine of great countries like "France, Germany, Russia, you will find that they have not got any. Russia prac- "tically has got no ocean-going steamers at all. She has got a certain number of "small coasting steamers of 200 or 300 tons burden. You will find that that is the "case with Germany also. I find in the returns that the mercantile marine of "North Germany is 48,000 men, which is about 12,000 less than the Royal Marine "of this country. No doubt at Bremen, and places of that kind, they have a few "large liners which go abroad; but if you come to examine the history of the mer- "cantile marine of all nations, except England, you will find it is practically insigni-

"ficant." I think Mr. Harcourt will allow that is disproved. (Mr. HARCOURT: Oh, no.) There is another fact I may call your attention to, viz., that if the mercantile marine of the North German States is not sufficient to satisfy Mr. Harcourt, still the mercantile marine of this country is enormous; the number of large steamers in this country is enormous, and it would be perfectly competent for any country that contemplated an invasion; and I am quite convinced if Germany ever did contemplate it she would make her provisions beforehand; it would be quite competent to them to buy steamers in this country for that purpose before declaring war. But as the question whether it is worth while to maintain our Army in a state of efficiency or whether it is not, I think you will all agree with me that it is not only a duty, but that it behoves this country in every possible way to take such measures and precautions, both with regard to her Army and her Navy, that her Navy shall be superior in strength to any force which is likely to be brought against it, and that the Army is also placed in such a position that it could with reasonable probability resist the force which with reasonable probability could effect a landing.

Vice-Admiral OMMANNEY, F.R.S.: I am very sorry to hear that my brother Officers have totally demurred to Mr. Harcourt's paper, because I think he is a friend to the Navy, and he has thrown out one suggestion which I think is a very valuable and important one, and which I hope he will follow up. He recommends that 200 or 300 gunboats should be provided; if that is done, it will be one of the greatest securities we can have to prevent any invasion. If we had 300 gunboats with means of steam propulsion, such as those which we are now constructing, each mounting an 18-ton gun, I think that alone would almost prevent an invasion of this country. Differing as I do as regarding the facility of landing 3,000 or 4,000 troops from one ship on an enemy's coast, I must say I do hope that when the enemy try to invade us they will come in ships carrying 3,000 or 4,000 men in each ship, because I believe myself that it would be impracticable to land 3,000 or 4,000 men fit for service from a ship, and to disembark their baggage and stores under 24 hours. I do hope, Sir, that from your place in Parliament you will advocate that which you put in your paper, and thus provide us with 200 or 300 formidable gunboats.

Lieut.-Colonel CHESNEY: I rise to say a few words, and would, in commencing, refer to what was said at the beginning of this evening with regard to a protest against shams. It seems to me that if we were, as suggested, to totally ignore all that has been said and written on this subject since we last met—not only in this country, for it has been largely discussed over in Germany—we shall be committing ourselves to a sham which might well send us all away ashamed of the unreality of such a proceeding. I am not too careful to ask how far Mr. Harcourt's views may have changed, nor do I wish wholly to force conviction upon him. Rather I think we owe him a deep debt of thanks for giving the whole country by its voice in the press the opportunity of stating straightforwardly what is the public mind upon this subject. And whatever the opinion may have been formerly about the utility of the Army, anybody who has studied the question as it has been discussed during the last three weeks, cannot doubt what it is now. The country is resolute in its determination, without rushing into either any wild excess or hasty reduction of armaments, to see for itself that it shall get the value of what it now engages for, so that having paid a handsome sum down it shall secure a handsome service for that sum; and it is plainly not less resolved that it will continue so consistently to act in this direction, that the possibility of the panics which have disgraced us over and over again in the eyes of all Europe for the last 15 years, shall vanish from our political horizon. I repeat, therefore, we owe Mr. Harcourt a real debt of gratitude for giving not only ourselves, but tens of thousands outside this Institution, the opportunity of considering whether really we have done too much, and of deciding deliberately on this consideration that too much has not been done yet, that we are only in fact now coming up to what is really required for the maintenance of our national security.

Captain COLOMB, R.N.: I wish to say that I am one of those who do not form part of the "hot bed" that has been described, for I find myself in very close agreement with much that Mr. Harcourt has said. I do not think that the "abstract" of questions propounded, which has been circulated to us, expresses the real points of Mr. Harcourt's argument. I understand him to propound two questions, first: is invasion

probable? and secondly, admitting it to be so, what is the proper method of defence? I think we must admit—at any rate, if Mr. Harcourt does not, the Meeting on both occasions seemed to me fully to admit—that there is great possibility of invasion, and I think that the military speakers have very distinctly proved that military preparations on shore will not prevent invasion. The only argument I have heard on that head which seemed to me to go to the point, was Colonel Baker's. He proposes that we should have such a military establishment as would create a feeling in the minds of our enemies that the difficulty of invasion would be very considerable. So far I think military preparations are right, but I think it seems most distinctly shown that, take it how we will, military preparations on shore do not suffice to prevent invasion. As was said by a previous speaker, there was no record of an invasion undertaken which did not turn out successful. (Captain Tyler: The Spanish Armada). I am merely quoting a previous speaker, I am not going to argue the point myself. Now I think that another point has always been put forward, and that is the great possibility of the Navy being out of the way when the occasion comes, but looking to history, I never see that the Navy was out of the way, but it had a particular policy in those days, which appears to me not to govern it now. Its policy then was to seal its enemies up in their ports. I take that to be the policy which will form the proper defence against invasion now. I look with considerable alarm upon the many plans that are put forward for retaining ships on the shores of England. I believe what would happen in that case would be false alarms, the withdrawal of the force from one point to another point; but if you provide sufficient force—and it does not require such a very large force—to seal the coast from Gibraltar to the Cattegat which we commonly did in the old war, we are quite safe from invasion, and we are safe from a danger which is far greater than that of any invasion in my opinion, we are safe from the danger of blockade. Looking at this question, it seems to me really our greatest danger now is the danger of blockade. You may take it that in round numbers the population of the British Islands has doubled within the century, but the commerce has multiplied eight times; that is to say, every person in England is four times as dependent on the commerce of England as he was during the last war. Then—I will not say what the figures are—but we are much more dependent for food than we were. (Captain Hoseason: One hundred and eighteen millions sterling of eatables imported every year). In the week ending the 25th of May, 23,000 tons of wheat came into this country. We cannot of course imagine what the state of this country would be with even a partial blockade; but if we take the only time in modern years when a partial blockade was attempted, I allude to the mutiny at the Nore, and if we remember what the state of alarm in the country was simply because the Fleet had the Thames in its hands, we can gain some sort of an idea of what the alarm and state of the country would be, were we to leave ourselves open to blockade. The only way to avoid being blockaded ourselves is to blockade our enemies, and therefore by throwing our force upon the enemy's coasts instead of retaining them on our own, and depending chiefly upon our own Navy distributed in that way, we should most effectually guard ourselves against invasion, and should also save ourselves from that far greater danger, blockade.

Mr. Vernon Harcourt: I may now perhaps be allowed my ten minutes for reply. In spite of my having come into a "hot bed of opposition," I have never for one moment regretted that I came here. People say vegetables grow in hot beds, and there is no reason why men should not grow in them also; it tends to promote ideas.

It has been said that I have changed my mind. Well, there is no reason why a man should not change his mind, and upon some points I have changed my mind, and upon others I have not. I have no doubt whatever on the question of transport that in the observations I made the other night I considerably exaggerated the difficulty. At the same time, after all that has been said upon the subject, I cannot at all agree that the difficulty has been entirely removed. I will first take the figures which I noted down carefully. Captain Dawson took my hypothetical army and estimated the amount of tonnage and ships it would take to carry it, and the figures he gave were 102 ships and 174,000 tons. When I look round to Captain Selwyn's fleet which is to carry any army to invade England, not my little army but a great army of 200,000 men—I think somebody else said 400,000, or any number of men—if I compare Captain Dawson and Captain Selwyn,——

Captain SELWYN: I did not say that, I only said they would each carry 3,000 men.

Mr. VERNON HARCOURT: Captain Selwyn gives us, I think, 35 vessels in those two fleets.

Captain SELWYN: Thirty-six, and 15 more will be ready within a year.

Mr. VERNON HARCOURT: I will take those that are ready at present, that will be upwards of 100,000 men. My army was very much less than that, it was less than half that, and Captain Dawson's figures require for that 174,000 tons and 102 ships. Now what is the tonnage of Captain Selwyn's great fleet which is to carry upwards of 100,000 men? Why, it is 108,000 tons, taking them at the average of 3,000 tons a-piece.

Mr. KNOX: Captain Selwyn only gives a few ships of the Hanse Towns. The tonnage of the Hanse Towns in 1869 was 700,000, but now it is 1,000,000.

Mr. HARCOURT: I am taking this fleet on the two slates, and I say, according to Captain Dawson's figures, it would not carry one-half of the army which I have suggested, of 30,000 infantry and 10,000 cavalry; he has taken my figures and carefully worked them out, and he says it requires 174,000 tons to carry them. Well, this great fleet which is to convince me that it can carry any force, evidently wont carry one-half of the small army that I have suggested, according to the comparative figures of Commander Dawson and Captain Selwyn, therefore it is not those figures that can convince me of the unlimited powers of transport, even of the fleet which is there exhibited.

I was asked by Colonel Baker whether I was not convinced that I was entirely wrong in saying the mercantile marine of Germany was comparatively insignificant. I do not know whether it was an error of mine or an error in the report. I was speaking, of course, of steamers, because we have been dealing with them all throughout. I meant to say certainly steam navy. I am not now talking of sailing vessels. I have before me a paper of the mercantile navies of the world, a letter addressed to the Editor of *Lloyd's List*, written, of course, without any reference to this question, dated 6th October, 1870, and it compares the steam navies of the world. Now the English mercantile steam navy has 2,426 vessels which is just 58 per cent. in point of number of all the steamers of the world, and it is 59 per cent. in point of tonnage. The American is 14 per cent., and what do you think is given in this table as the mercantile marine of Germany, to show that the statement that I made the other day was not made altogether without foundation? "The German marine is 127 in number, and 105,000 in tonnage." I have no doubt it has been increased since, I have no doubt it is much larger than it was then, but I am showing what proportion it bears—105,000 in tonnage—therefore the whole of the mercantile marine of North Germany would not have sufficed to have carried one-half my hypothetical army, and those vessels average 827 tons a-piece, taking the average all over them, and the mercantile marine of Germany, whereas that of England was 59 per cent. of that of the world, that of Germany was 3·7. No doubt the thing has been exaggerated, but I confess, taking Captain Dawson's figures, there is nothing to show me, upon those two slates, that there exists at this moment in North Germany a tonnage according to the estimate of Captain Dawson which would carry an army such as I have suggested. We are told that you may put 3,000, or even more, upon these vessels, and that is said upon the authority of some gentleman in Liverpool, who I am not aware has had experience in carrying troops. I have laid before you some figures of what our own Government are doing at this moment, and what the tonnage is. Now they have estimated that a ship of 1,500 tons will carry 138 horses and 200 men, and that is a measure of actual fact. [A MEMBER: On a long voyage.] No, between England and Ireland. I am speaking of the transport between England and Ireland. I also gave these figures, I think it was before Colonel Baker came, that these vessels of 1,500 tons were constructed to carry a regiment of infantry, 1,200 men, or they would carry 138 horses and 200 men. Taking it upon the average of the trips that have been made by ten vessels of 6,244 tons, they have carried 953 men and 835 horses, that is 95 men and 83 horses per ship of 600 tons. Those are very different figures from those that have been suggested, but that is what the Government is now doing, and has been doing for many months in transporting troops at a cheap rate to Ireland, instead of carrying them by

railway. These are the actual facts, as we can do it between ourselves, and do it as we think to the best advantage. That works out 160 men—of course I am giving the figures of carrying cavalry upon all these journeys, 160 men and 140 horses per thousand tons.

I have dealt with the figures given by Captain Selwyn and Captain Dawson, and I now come to Captain Tyler. He says that we are to defend Canada by invading America. I do not enter upon that subject, it seems a large one, but at all events there is one country that does not seem to be very much afraid of being invaded by us, and that is America, for America is a country not wanting in energy or wealth, and yet America, which Captain Tyler proposes to invade for the purpose, if necessary, of defending Canada, has no navy to speak of, and keeps an army of less than 30,000 men. Therefore, at all events, America is not in dread of invasion by a country which possesses an army at least three times as numerous as its own, and those fears, and perhaps that absence of prudence in respect to insurance, has not yet entered the American mind in reference to that invasion which Captain Tyler seems to have contemplated. I do not know if we can invade America, if so I suppose America can invade us, yet I have not heard in any of this controversy a discussion raised as to the number of thousand men we are to keep on foot to defend us against American invasion, because America has much larger vessels, no doubt, in many respects even than Germany. [Captain TYLER: No.] They have had since the late war, no doubt. I have seen myself in Liverpool some of the American liners; I believe since the late war the mercantile ships are of a much lower order, but you will find that we have about six times the mercantile shipping and steamers of that of Germany. (Captain TYLER: Not large ocean steamers). The average of tonnage is rather higher; the average of their 600 steamers is 860 tons as against an average of 827 tons over the 127 steamers of Germany, therefore in fact they are about five times as large in number, and a little larger in tonnage.

I shall not follow the criticisms of Captain Home. No doubt he was speaking to an audience where he was sure of a majority, and he thought it right to speak with severity of the "legal mind." I shall not attempt before so unfavourable a jury to defend the legal mind, only all I can assure Captain Home is, if ever he comes into our legal circle I shall not follow his example, and I shall not choose that opportunity for making an attack upon his profession. There is only one remark that fell from him which I think it is necessary that I should notice. He says the art of war does not consist in being the strongest. He made that remark with reference to some of the campaigns of Napoleon. That seems to me rather in my favour, for if the art of war does not consist in being the strongest, why are you to multiply your forces to this extent? I thought that we were to multiply our Army because it was assumed the most numerous army was most likely to win, but he says no, it is the outsider that always wins, and not the favourite. Then why should not we be the outsider, if it is the outsider who wins? I cannot conceive why we should endeavour to put ourselves in the position of the strongest, to make ourselves that favourite which is sure to be defeated. Captain Home's argument is an argument for having no army, because he says it is not the strongest that will win the war. (Captain HOME: Strongest at the given point). Then let us be strongest at a given point. That argument is one which it appears to me we ought to avoid. Certainly I have failed, no doubt from the defects of the legal mind in apprehending the art of war, and if the art of war does not consist in being the strongest, why surely all these armies are more than ever in vain.

Now, I have few remarks to make upon the important remarks of Colonel Baker. I think Colonel Chesney said something about my having confused the figures with reference to England and Ireland. I may as well correct that. I stated I think the United Kingdom, and I gave the figures. The men of all arms in England are 1,292 household cavalry, and 11,889 cavalry of the line. I am told that if the cavalry have not got horses they are no use: but I do not know why we do have so many more cavalry than we have horses if they are of no use. I thought we kept fewer horses, because when you had a good cavalry soldier you could mount him in a short time; if it is true that a cavalry soldiery is not worth counting if he has not a horse belonging to him, it seems to me we ought to diminish the number of our cavalry by one-half. Therefore I think that, at all events, is a valuable hint. Inasmuch as we have got at

the present moment 13,000 cavalry and we have only got about 7,000 horses, then it is plain that if the cavalry soldiers without the horses are no use, we ought to cut off about 6,000 cavalry soldiers who have no horses. (Colonel OUVRY: Or provide the horses). Or provide the horses. In one way we must have a greater expenditure, in the other way we might have a larger economy; but it is quite plain that this existing as it stands, cannot be right, because we must have 6,000 men who are of no use at all. I am going to figures as they stand. There are 13,000 cavalry, of which about 9,000 are in England; that is pretty near the figure at which I put it: 2,580 Royal Horse Artillery, 3,000 Royal Engineers, 42,000 Infantry, including Foot Guards, making in all about 72,000 men and about 27,000 in Ireland.

Major-General Sir PERCY DOUGLAS: That includes the Indian depôts, does it not?

Mr. HARCOURT: Whether it includes depôts or not I cannot say.

Sir PERCY DOUGLAS: I may say that it does, and that they number 9,000.

Mr. HARCOURT: But I suppose the Indian depôts can fight, at least I hope so; they are very little use to send out to India if they cannot, therefore I do not exclude them at all from my calculation, because, if you have troops fit to be sent out to India, I suppose they are troops that could fight for the defence of England.

Sir PERCY DOUGLAS: It merely represents the potential number we may raise in the year in order to recruit the casualties in the regiments in India; it represents no fighting power at all, they may not be in existence.

Mr: HARCOURT: These are the actual troops on the 1st of May, the date given by Colonel Chesney, the actual troops in existence under the colours in England. Colonel Chesney, no doubt, is familiar with the paper.

Sir PERCY DOUGLAS: A great many of them have not even the clothes.

Mr. HARCOURT: I think Colonel Chesney will admit these figures that I have taken are given from a correct and official paper.

I do not know that I have anything more to say. There is one point upon which Colonel Baker has I must say convinced me, and has brought the matter very strongly before my mind, and that is the very great difficulty of preventing a landing by land troops, that is to say, that the power that troops embarked have of moving along the shore, and so baffling the pursuit of land troops, is very great. I think Colonel Baker has brought out that fact in a very strong manner. I confess the impression left upon my mind is that if you have got 3,000 men in one vessel, or 30,000 men in ten of these vessels, I should like to fight those 30,000 men when they were inside those vessels, rather than when they were outside. The more men you get into a ship, the more I should like to fight them in that ship, for if you get all your eggs into a basket of that kind they may be cracked by a single shell. The Prussians are prudent men I believe, and how far they would venture 3,000 men in a ship which a single shell thrown from a gunboat, or from a Cunarder with a gun on board, might send to the bottom, is a matter which of course scientific people will judge of. When you have got, practically speaking, a whole *corps d'armée* put into ten of these boats, that a single gunboat with an 18-ton gun on board, if it once got at them, would send to the bottom at once, it would be a catastrophe that has never happened in any land engagement that ever was fought; and if you can send three regiments to the bottom by a single shot, that is a thing no land force you ever created, has ever yet or will accomplish. If you can get an army into that condition, it seems to me that that is the situation in which you would most desire to get them, and to fight them when you get them there.

I am extremely obliged to the Institution for the kindness and courtesy with which they have allowed me to come here to learn a great deal from them. Colonel Chesney has been good enough to say he thinks that the discussion has been useful, though not probably in the direction in which I hold it; but still he admits, in an opposite direction. I have always thought, anybody who aspires to take any part in public affairs is bound, when he has his opinions, not to go and deliver them to ignorant audiences, who will believe anything that he says, if he has anything to say, whether it is right or wrong. It appears to me the part of any man who is to do any good to himself or anybody else, is to submit his opinions to the test of those who can confute them, if they are to be confuted; and therefore when I was asked to come here, I felt that I could not in honour and in manliness refuse to come before this Institution, and in the presence of officers of both professions (who could confute

anything I have to say), to say what I had got to say ; and all I can say is, I have had great pleasure in coming here, and if I have in any way, even contrary to my own opinions, succeeded in throwing light upon this question, the only object I ever had in coming here, has been fully answered.

The CHAIRMAN : I am sure we must all thank Mr. Harcourt for coming forward in answer to the request of our Council ; and not only for the able manner in which he has brought the matter before us, giving a good shock to preconceived notions, I have no doubt, on both sides, but also for the extremely courteous and patient manner in which he has carried on his part of the discussion. I must say, I hope that whatever we may think of the legal mind, we shall strive, at all events, in all discussions, in all papers, and at all our meetings, to take a leaf out of his book in these respects.

APPENDIX.

DIMENSIONS OF A SHIP OF 3,464 TONS BURTHEN, PLANNED FOR THE AUSTRALIAN DIRECT COMPANY (VIA PANAMA) OF 1854.

	feet.
Length of keel	326
Fore-rake	8
	334
Beam moulded	45
Depth of hold	32
Tonnage, old measurement	3,306
Tonnage, new measurement	3,464
Engine space	1,022
Tonnage for Custom dues	2,442

Displacement at load-water line, 26 tons per inch.

Estimated Weight.	tons.
Hull	1,600
Spars, sails, rigging	75
Water and stores	350
Engine and boilers	640
Coals	1,500
Cargo, dead weight	837
	5,002

Total weight on board, drawing 21 *feet of water from top of keel.*

	tons.
Total displacement	5,002
Weight of coals, water, and stores	1,852
	3,150

Being displacement at light-water line 15 feet from top of keel, or 15·9 inches draught of water.

Cargo.	feet.
Contents of forehold	50,874
„ afterhold	37,789
After between decks	17,640
Fore between decks	3,780
	110,083
Deduct space for coals, 1,500 tons	72,000
	38,083

952 tons at 40 cubic feet, being space for cargo alone, exclusive of store, icehouse, &c.

Carrying Capacity.

837 tons dead weight, or 952 tons measurement.

1 ton	=	2,240 lbs. =	food for	1,000 men, or	100 horses.
100 tons	=	224,000 lbs. =	„	100,000 „	10,000 „

1 ton	=	10 mules' burden, or	3 Maltese carts carrying 7 cwt. each.
100 tons	=	1,000 „ „	300 „ „ „

The ship has on each deck 15,000 square feet—

24	square feet is space for	1 horse, or	2 men.
100	„ „	4 „	8 „
1,000	„ „	40 „	80 „
15,000	„ „	600 „	1,200 „

Screw Steamer "Adriatic" from Liverpool to New York.

Length	452·6 feet.	Gross tonnage	4250
Breadth	41 „	Net register	2950
Depth	32 „	Horse-power	600
		Indicator	3000

Superficial area of deck .... 18,532 feet.

The ship is capable of carrying :—

150 saloon passengers
1000 steerage passengers

Total .... 1150 passengers.

Extract from a Paper on the Disembarkation of Troops, by Captain Sir W. Mends, C.B.

The British portion of the expedition to the Crimea consisted of 120 sail, including :—

10 ships of the line (2 being screw steamers).
4 frigates (1 being a screw steamer).
11 steamers of war (paddle and screw).
24 steam transports (including 3 of Her Majesty's).
7 steam tugs.
64 sailing transports.

120 total

The force (British) to be disembarked consisted of—

30,000 infantry.	1,624 horses for guns.
2,192 artillery.	1,530 horses for cavalry.
1,240 cavalry.	65 horses for Staff.
	160 horses for regimental staff.
33,432 men.	3,379 horses.
54 guns.	

Number of boats employed in landing men 326
Number of horse and gun flats 24

The *Allied* flotilla, when at sea, numbered somewhere about 400 sail.

Transport Department during the Second Year of the Crimean War, as shewn by Parliamentary Returns.

		Tonnage.	Horse power.
Maximum number of steam transports employed..	102	121,060	26,317
Maximum number of sailing „ „ ..	115	93,172	
Total	217	214,232	

Number of Officers and men employed in the above, about 9,256
Mean of average tonnage of the steamers 1,196
Mean average tonnage of the sailing vessels 810

Entire means of transport in the Black Sea at the time of invasion, 125 ships, including men-of-war (*vide* Evidence of Vice-Admiral Dundas before Mr. Roebuck's Committee).

Estimate for Transport Service, 1854–55	£3,582,474
Estimate for Transport Service, 1855–56	£5,181,465

SPACE OCCUPIED BY INFANTRY AND HORSE ARTILLERY ON BOARD SHIP.

INFANTRY.

1 regiment consists of 1,000 men and 17 horses.		
1 man occupies 12 square feet; 1,000 men require	12,000	square feet
1 horse occupies 24 square feet; 17 horses require	408	,,
	12,408	,,

HORSE ARTILLERY.

Space occupied by—		Super. feet.
1 12-pr. Armstrong gun and limber with the shafts out..	14′ × 6′	84
8 horses for ditto, each horse	8′ × 3′ = 24 =	192
		276
1 ammunition waggon	14′ × 6′ =	84
6 horses for ditto	8′ × 3′ = 24 =	144
		228

1 battery consists of—		Square feet.
6 guns, each occupying 276 square feet	=	1,656
6 Officers and 243 men, each man 12 square feet	=	3,000
11 ammunition waggons, each 84 square feet	=	924
11 spare waggons and carts, each 84 square feet...........	=	924
224 horses, each 24 square feet	=	5,376
		11,880

1 regiment of infantry requires	12,408
1 battery of horse artillery requires	11,880

LECTURE.

Monday, July 8th, 1872.

General Sir WILLIAM J. CODRINGTON, G.C.B., Vice-President, in the Chair.

THE PRACTICAL INSTRUCTION OF STAFF OFFICERS IN FOREIGN ARMIES.

By Captain Frederick G. Burnaby, Royal Horse Guards.

"The art of war" has greatly changed during the last fifty years, and railways and telegraphs have given it quite a different aspect to that which it originally possessed. Topography was formerly but little known; maps were few and far between, not many Officers had the aptitude to read them, and Generals used to trust much more to their guides than to the frequently inaccurate maps then published. Armies are much larger now than they have ever been during the annals of modern warfare, it was formerly so difficult to feed a large army, and railroads did not exist; roads were few and often impassable, supplies were cut short, discontent was the consequence; the army became demoralised, and defeat was inevitable. But if armies are much larger now than they have been during the annals of modern warfare, it must not be forgotten that in the earlier pages of the world's history, enormous forces took the field. Herodotus tells us that Xerxes invaded Greece with an army which exceeded five millions of men, with its combatant and non-combatant strength. But war in those days was not conducted on the same civilised and, comparatively speaking, humane principles as at present. The conquered had to supply the conquerors with every means of subsistence that lay in their country; and those wretched sufferers who were not killed or sold as slaves, had no alternative left but to die of hunger.

But notwithstanding the exacting manner in which warfare was carried on in those early days, every now and then we read of special instances of large expeditions having their ends entirely frustrated owing to a deficiency in the Commissariat. For instance, Darius, King of Persia, crossed the Bosphorus 513 B.C. on a floating bridge, and

led his army of 700,000 men into the country which lies between the Lower Danube and the Don—a country, by the way, which it is interesting to study now, as it may again be the theatre of military events, perhaps sooner than we think. The Scythian retired and carefully avoided battle; Darius pursued; but in those wild steppes there were no means of feeding his army, and eventually he had to beat a retreat. Some historians say that many thousands of his men died of hunger. Again, Alexander of Macedon, on his homeward return from India, divided his forces into three columns. The southern column he sent by ships; the centre one along the coast; and the northern one he led himself through the desert plains of Gedrozia. Here there were no means of feeding his troops, and 80,000 men, or two-thirds of his army, perished, principally from hunger. Again, in later years, General Dumouriez's expedition, at the latter end of the last century, was a failure principally on account of the deficiency of his Commissariat arrangements; and, finally, we have but to look back to the year 1812, and to perhaps the most distinguished General that ever lived, and who had planned his campaign in Russia with the greatest care and forethought. But how disastrously it ended, owing to his army being cut off from its supplies when in an enemy's country.

I think I have given you instances enough to prove that in all times and in all ages, one of the greatest difficulties that a General has had to contend against, has been to feed his troops when he has been in an enemy's country.

I now propose to tell you what is done by the Prussian, Russian, and Austrian military authorities to ensure having in their Commissariat, or, as they call it, "Intendance" Department, Officers thoroughly acquainted, both practically and theoretically, with every part of that branch of the profession.

In Prussia, every Officer who wishes to enter the "Intendance" Department has to pass an examination. He has to know all the various divisions of the Prussian Army, and the relation of the separate military commands to the higher civil and military authorities; also the rights and duties of the military administrative depôts with reference to the separate military commands. He has to possess a qualified knowledge of finance, and a thorough knowledge of military economy in times of peace and war. In addition to this, he has to know all statistics relating to the clothing and feeding of an army. No Officer is admitted as a candidate to this examination unless he has served six years with distinction in the regular Army. In some few cases, junior Officers of the Intendance are admitted as candidates; but then they must have shewn special aptitude for their profession, and have served previously in the Line or in the Reserve.

In Russia, the Staff Officers of the "Intendance" have not only to know all the resources of their own country, but they have to know all the resources of every country with which Russia may at any time have to go to war. It is not sufficient for them to know that the country in question is rich, but they must know in what that richness consists, whether in corn or in pasturage, whether in commerce or in manufactures. They must know the network of railways of the country

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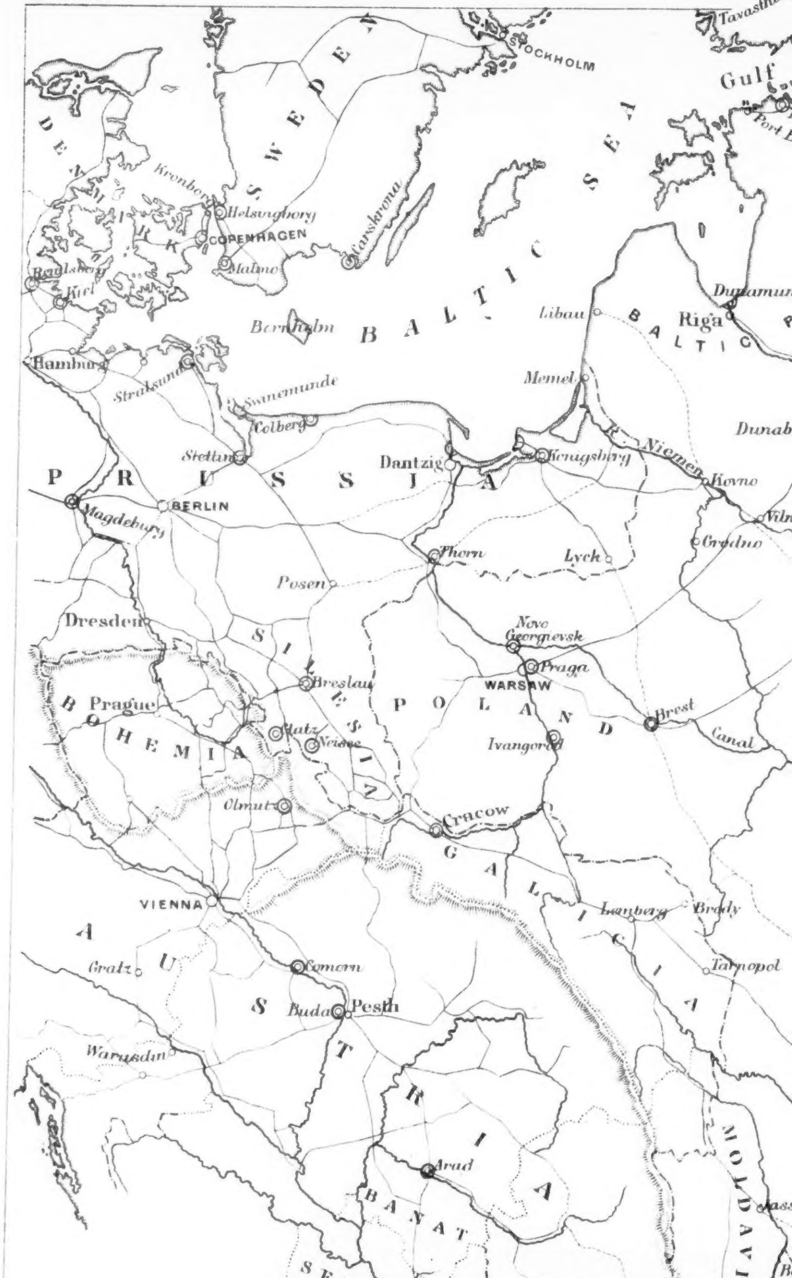
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Bornholm
Libau
Riga
Dunamunde
BALTIC
Hamburg
Stralsund
Swinemunde
Memel
Colberg
Dunaburg
Stettin
Dantzig
Konigsberg
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Kovno
PRUSSIA
Magdeburg
BERLIN
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Thorn
Lyck
Grodno
Posen
Dresden
Novo Georgievsk
SILESIA
Praga
WARSAW
Breslau
Prague
BOHEMIA
Glatz
Neisse
POLAND
Ivangorod
Brest
Canal
Olmutz
Cracow
GALICIA
VIENNA
Lemberg
Brody
AUSTRIA
Gratz
Comorn
Tarnopol
Buda
Pesth
Warasdin
MOLDAVIA
Arad
BANAT
Jassy
SERVIA
Kronstadt


Tavasthus
Sweaborg
Viborg
Gulf of Finland
Cronstadt
St PETERSBURG
Revel
Port Baltic
Oranienbaum
Peterhof
Kolpino
Zarskoe Selo
Canal
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R. Sukhona
Vologda
Looga
Novgorod
PROVINCES
Pskov
Dunamunde
Ostrov
Ribinsk
Iaroslav
Kholm
Tver
Dunaburg
Rjef
Voskresensk
Tuschino
Volokolamsk
MOSCOW
Nijni Novgorod
Kovno
Vilna
Grodno
Witebsk
Smolensk
Viasma
Minsk
Tula
Canal
Orel
Kozlov
Griazi
Koursk
Voronez
Kiev
Tarnopol
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SEA OF AZOV
Fortresses thus

J. Jobbins

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in question, and in what way they are connected with the Russian railways. They must be able to speak French and German, and be able to state how many Russian troops could be fed in that country in the event of war, by means of "requisition." We read in a very interesting article in the "Voennye Sbornik," or "Russian Military Magazine," a magazine, by the way, in which the articles are written almost entirely by Officers of the Staff, and which is edited by Major-General Menkoff, of the Russian Staff, that Bohemia, which is one of the richest countries in Austria, and which has a population of 5,000 people to the square mile (German mile), would not long be able to support a foreign army, as the richness of Bohemia consists principally in its manufactures, but that in Hungary, Wallachia, or Banat, a foreign army would be able to subsist for a very long time, provided only it had sufficient mills to grind the corn, which is the principal produce of those countries.

The "mill" question is an important one as connected with the Commissariat. The Russians have not forgotten that shortly before the outbreak of hostilities in the Crimea, they had 140,000 quarters of wheat lying in the ports of the sea of Azov ready for shipment to Europe; but this corn was almost all lost to them, owing to their having but very few mills to grind it. We know that Napoleon, previous to his expedition to Moscow, ordered 5,000 hand-mills to be sent with the troops. The order was fulfilled too late, and the mills did not arrive till he was on his retreat from Moscow, and when they arrived, there was nothing for them to grind. Now, if you will follow me through a small calculation, you will see how important the "mill" question is. For instance, let us suppose that Silesia has 2,000 people to the square mile, and that there are mills enough there to grind corn for 3,000. Now, let us presume that an army of 360,000 men is brought to bear upon that country. To grind corn for such a force, it would require that all the mills extending over an area of 120 square miles should be kept going day and night. You can see clearly what a difficulty that would be in the event of war.

The Austrians became so thoroughly aware of their shortcomings in the "Intendance" after the battle of Königgratz, that they determined to start a special military school for all men who wished to acquaint themselves practically with the Commissariat department. And in addition to this they instituted a two years' course of military instruction at the Academy for all Officers who wished to enter the "Intendance." The course of instruction and the system of examination is very similar to what takes place in Prussia. I need not, therefore, detain your attention any more on this subject.

There is yet another element in modern warfare to which great importance is attached on the continent. I allude to railways and to the military carriages for all arms which foreign countries now possess, and, in addition to this, to the military railway commands; and how Officers and men are both practically and theoretically taught everything connected with the railway department. Railways in modern warfare occupy such a very important position as a means of rapidly mobilising and feeding troops, that it is not to be wondered at, that in

Russia—which is a country where the want of railways was so signally felt during the time of the Crimean war—great attention has been paid to this matter. In June, 1869, a special committee of Staff Officers was ordered to sit at St. Petersburgh and to report upon the nature and number of military railway carriages for all arms that every railway company in Russia should be compelled to keep. The result of their deliberations and recommendations was forwarded to the Emperor and signed by him. At present in Russia all the railway companies have to provide a certain number of carriages for wounded, fitted up with litters, and well ventilated; also a number of trucks, specially fitted up with every appliance for the transport of heavy artillery in the event of war; and, in addition to this, a large number of horse-boxes or horse-trucks; and there seems to be a very useful device in connection with them, for they are so contrived that the sides of the trucks can be let down and formed into a bridge, so that the cavalry can be got out at any point on the line without waiting for their arrival at a station. The railway companies have also to provide a large quantity of carriages fitted up with racks and every sort of contrivance for hanging up soldiers' knapsacks and arms. At present in Russia they have enough of these carriages to transport 54,000 infantry, 1,500 cavalry, a proportionate quantity of artillery, 1,464 slightly wounded, and 732 severely wounded men; and the railway companies are still constructing more of these carriages.

In imitation of the Prussian military "railway commands," which proved of such signal use during the Austro-Prussian war, the Russians determined to institute a force of their own, founded on the same model. For this purpose they dispatched 432 men and 8 Officers to all the different railways in Russia. This was three years ago. The men had to learn both practically and theoretically everything connected with the management of the line, and the Officers were ordered specially to study the duties of station-masters. In June last year it was thought by the military authorities at St. Petersburgh that it would be a very useful thing to ascertain in some manner the exact amount of knowledge which every Officer and man had attained in his new calling. For this purpose it appeared that the best possible means would be to construct a railway during the manœuvres. This was determined upon, and it was resolved to unite the Peterhof and Warsaw lines, and make a branch from the Ligovo station to the ninth verst of the Warsaw line. This line, if left standing, would be very useful as a means of connecting Peterhof with Tsarskoe and Krasnoe Selo; and if prolonged as far as Kolpino, on the Nicolaieff line, it would facilitate communication with Oranienbaum, where it had been proposed to construct a port. This Nicolaieff has nothing to do with the Nicolaieff near Odessa, but the railway is called Nicolaieff because the Emperor Nicholas was the person who ordered its construction, and it was the first line laid down in Russia. Major-General Annenkoff, of the head-quarters' staff, was requested to take command and to make all the necessary arrangements. The men and Officers who had been sent to the different lines were telegraphed for to come to St. Petersburgh, and on their arrival they were formed into two companies of 216 men

and 4 Officers in each company. In the companies there were engineers, engine-drivers, stokers, guards, constructors of trains, pointsmen, signal-men. The 22nd infantry division and one reserve engineer battalion were ordered to assist in the work. The whole length of the line, I should have told you before, was eight versts, or seven miles. The work was commenced on the 28th of July, and it was finished on the 4th of August. There were two stations constructed, one at each end of the line, and ten bridges, one over the Ligors Canal, which is there more than 50 yards broad. The Emperor was so pleased with the celerity with which the work had been performed that he was determined it should be left as a permanency. The entire expense of it to the country was 150,000 roubles, or a little more than £21,000, and it is said that the Government will not be a loser by the transaction, for the exploiting of the line will thoroughly pay for its cost. Russia is more dependent upon these military railway commands than perhaps any other nation, because almost all the men who are working on the line from Vilna to St. Petersburgh are either Poles or Germans, and in the event of war, it would be necessary to replace them with Russians. For this reason Russia has more reason to be particular about these matters than either Prussia or Austria.

There is, however, yet another military element, which I am now going to speak to you about. This element in warfare is perhaps the most important one of all; for no matter how well a campaign may be planned, no matter how skilful the General who plans it, if his subordinates during the time of war do not properly execute their independent trusts, signal disaster is sure to take place. I allude to "strategy." For let us imagine that a country has an army, that that army has its railway commands in the highest possible degree of efficiency, and that its Commissariat is perfect; let us further suppose that that army is well clothed, well armed, and well disciplined. Still, the nation which possesses such a force cannot even then be assured that it has a trusty defence in the moment of danger; for it is necessary to give all armies in time of peace a thoroughly warlike education. Sad will be the fate of those forces whose leaders think that the moment of commencing hostilities is the moment for commencing, and not for terminating, their military education. Bravery and superhuman exertions will not compensate for the want of strategy in modern battles. The "Kriegs Spiel," or war game, is an admirable means of theoretically studying the art of war in time of peace. It may be made most useful as a method of studying tactics and learning the ground over which double manœuvres, or what we call "autumn manœuvres," are to take place. But where Prussian and Russian Officers find the "Kriegs Spiel" of such advantage is, that they are enabled by it to play the game over a foreign country, where they have no opportunity of manœuvring their troops until actual warfare commences.

In England the "Kriegs Spiel" has to be played with the 6-inch map; for the Ordnance survey 1-inch map is too small; and while I am on the subject of maps, and as maps play such an important part in modern warfare, perhaps I may be allowed to make a few remarks with reference to our own Ordnance survey. The English

Ordnance survey map, as far as its trigonometrical lines go, is perhaps the most accurate one that has ever been published; in fact it is so accurate that I remember last year Captain Moncrieff, the inventor of the celebrated gun carriage that bears his name, saying that he believed it would be possible in the event of war and of a foreign foe being on our shores, to place a battery of guns behind a hill, and then to send out an Officer to mark down the exact point where the enemy were, and if they were not more than a mile off, he would be able, without seeing the enemy, to shell them from their position, and by means of the map, direct his guns and make the shells fall into a piece of ground not larger than 100 yards square. But if the English Ordnance survey map is so wonderfully accurate as far as its trigonometrical lines go, it must not be forgotten that it is a very old survey, and does not represent the present actual condition of the country. A country changes very much. Roads are turned, roads are altered, fresh roads are made. What was marsh is now cultivated ground; what were woods may be arable country; and what were arable grounds may now be woods. If we take the Ordnance survey map of England and draw a line from Essex to Glamorgan, and again from Cornwall to Kent, we find that the intermediate country was surveyed in 1816. Since then the railways have been inserted; but the roads remain in exactly the same state on the Ordnance survey map as they did in that year. Again, if I turn to sheet 8, counties of Surrey and Hampshire, I see that this map was published also in 1816. Since then the railroads have been put in, and the camp at Aldershot; but the roads five miles from the camp remain exactly in the same state on that map as they did fifty-six years ago. It is true we have the 25-inch parochial scale map, but this is a partial map, and not the Ordnance survey. I cannot help thinking if the "Kriegs Spiel" could be played on a raised or modelled map, showing the height of the hills and the ridges, it would be a great advantage, especially to artillery Officers.

Double manœuvres, or what we call "autumn manœuvres," are undoubtedly the best means in the world, short of actual warfare, for teaching Generals strategy, provided that the number of men employed on both sides is sufficiently great to make their handling as intricate a matter to the Officers concerned, as it would be in actual warfare. But manœuvres are costly things. Again, in England they can only take place once a year, on account of our climate and our agricultural conditions; and in some counties they cannot take place at all without great opposition being made to them by the game and landed proprietors. Now, in the event of war, and of Mr. Vernon Harcourt's theory proving incorrect, we cannot expect our enemy to ask our opinion as to which should be the best route for him to move upon London. It is, therefore, advisable that the closer and confined counties should be as well known to our Staff Officers, as the more open expanses of country, which are in England, alas! becoming each year more scarce. Again, double manœuvres, though admirable practice for Generals, are not so beneficial to Colonels, particularly to junior Colonels, who only command their own battalions; because these Officers have exactly the same command in the "autumn manœuvres" as they would have in

their own barrack field. In addition to this, on returning to camp each evening, they have their time so thoroughly occupied with the care and management of their horses and men, that they have but very few moments left to consider what have been the tactical problems of the day. Now the very men who are now Colonels commanding regiments, in all probability in the course of a few years—or, if war should take place, much more quickly—may be Generals, and then we might see the strange anomaly in the nineteenth century, of Officers placed in positions of high responsibility, who had not been sufficiently prepared for them in time of peace.

The Russian military authorities have long had their attention drawn to this question. They saw plainly that their autumn manœuvres would only be a source of useful instruction to the senior Colonels and Generals; it was therefore determined to institute some means of practically teaching their junior Colonels and other Field Officers the higher commands in warfare. For this purpose they resolved to send out parties of Staff and Field Officers from every military district into which Russia is divided, to divide each party into two sides, and to let them manœuvre against each other exactly in the same way as they would during the grand manœuvres, but with this difference, that the armies, divisions, and brigades should be skeleton ones, and that two or more infantry men should represent an infantry regiment, two or more cavalry men a cavalry regiment, and a gunner a gun or a battery, as the case might be. Two similar expeditions were sent out from the head-quarter Staff of St. Petersburgh in the spring of last year, and three others were sent out from Moscow, Kiev, and the Warsaw districts in the autumn. My present object is to tell you what was done by the party of Officers who were sent out in the Moscow district.

Before I commence, however, I must tell you that the subject of manœuvres is naturally a dry one, and full of details; but I will endeavour to make them as clear and interesting as possible by means of this large military sketch. It is taken from a Russian military map which was drawn out by a Colonel of the Russian Staff. This rough military sketch shows all the fortresses in Russia, and it also shows the railroads, and their connection with the Austrian and Prussian railroads. I know that many people in England look upon a war between Prussia and Austria against Russia as a great improbability, but I can assure you that Prussian and Austrian Staff Officers do not think so. I have often heard people in England say, "Ah, but remember the friendly "relations that exist between the two countries; and look how well "Prince Frederick of Prussia and General Moltke were received at St. Petersburgh last year." Did family connection preserve his throne to the poor King of Hanover? and was the reception given by the Emperor Napoleon to the King of Prussia a few years ago one whit less hospitable than that shown by the Russians to the Prussian Prince and to General Moltke. There is a great deal of difference between saying what you think, and thinking what you say. Do you think Napoleon said what he thought to the King of Prussia, when he paraded his Imperial Guard before him in Paris? And was not King

William himself, perhaps, an example, a living example of the old adage or saying attributed to the celebrated French philosopher, that "words were given to man to disguise his thoughts."

I remember hearing an admirable speech made two years ago in the House of Commons. The orator, after alluding to the causes which led to the Franco-Prussian war, said, no man in Europe who has carefully followed the course of political events during the last few years, could have failed to observe that after the battle of Sadowa, there was a train of gunpowder laid from Berlin to Paris, which only required the spark to set Europe in a state of conflagration. It is the opinion of many people in Prussia and Russia, amongst whom are Officers and persons whose opinion is well worth having, that after the battle of Sedan there was a train of gunpowder laid from Berlin to St. Petersburgh, which only requires the death of one aged monarch to kindle not only Europe, but also part of Asia in one general bonfire. I know some people in England think that we have reason to apprehend Russia in India. This is a question which, though now like a cloud no bigger than a man's hand, will as certainly loom up in the far-off future, as that the Southern States of America will at some distant period again try to cast off the hated yoke of the Northerners.

But you may ask me why should Austria be dragged into this war? If Prussia and Russia go to war, nominally on account of the Baltic provinces, but in reality and as is the case in most wars for the sake of statesmen's ambition, and for the desire inherent among nations as amongst men, to determine which is to be the master, it would be far more disadvantageous for Austria to remain neutral than to throw her sword into the same balance as an ally with her late foe. Poor Austria! the Kaiser who rules her heterogeneous empire has a difficult task to perform in endeavouring to govern a variety of nationalities, who all want to govern themselves; and in the event of victory or in the event of defeat, Austria's lot will be equally an unenviable one. Her eight million Germans, and sixteen million Sclaves and their territory are as tempting a morsel in the eyes of Prussia and Russia as Naboth's vineyard was to the Jewish King.

But I must return to the manœuvres, and I will now tell you what was done by the party of Officers which went out in the Moscow district. It consisted of 2 Generals, 16 Staff Officers, 29 Field Officers, 2 Officers of the Intendance, and 3 medical men; 75 infantry soldiers, 60 cavalry soldiers, and 28 artillerymen, were ordered to join the expedition to act as markers, and 120 horses were attached to it for the use of the Officers during their exercise in the field. The following was the plan of the manœuvres:—A western army, evidently a Prussian one, has crossed the River Niemen between Kovno and Grodno. I should here tell you that the Russians intend to build a fortress at Kovno. They have all the plans drawn out for it, but the works are not yet commenced. Well, this army has crossed the River Niemen, between Kovno and Grodno, has invested Dunaburg, and occupied Pskov, and from Looga it marches on St. Petersburgh. A southern army, probably an Austrian army, in alliance with the western one, has occupied Jitomir, and from Jitomir marches on Kiev. A detached force

of the western army, after the occupation of Pskov, receives orders to march forward and clear the line of operations for the main body, and then to march on through Rjeff to Volokolamsk, and thence to Moscow, if possible to occupy Moscow, and to prevent the formation of reserves for the eastern army, which was defeated at a battle supposed to have taken place when the western army crossed the River Niemen between Kovno and Grodno.

The Officers having been divided into two sides, one side was assumed to represent the party marching from Pskov on to Moscow, and the other was supposed to be a detached force of the eastern army stationed at Voskresensk, with the view of impeding the attempt of the western army to take Moscow. This was the plan of campaign. The assumed strength of each of these detached forces was three divisions of infantry, eight regiments of cavalry, and a proportionate quantity of artillery, one engineer battalion, one pontoon half battalion, and a railway command. The colonel of an infantry regiment was to command one side, and the colonel of a cavalry regiment the other. Previous to commencing their operations, the Officers on both sides had to go through a preliminary course of instruction. The Officers of the western army had to study the military topographical description of the road between Pskov and Moscow, and had to give a detailed account of the railroads, roads, and other means of communication. They had to ascertain the numerical strength of every division in their assumed army with reference to existing statistics, and to state the best manner of forwarding troops through Pskov and Ostrov to Volokolamsk. They had also to send in reports upon the best means of covering their front during their march, and of keeping up their line of communications, and to state where it would be most advisable to leave depôts, and the quantity of men that it would be necessary to leave at each depôt for its defence. The Officers of the "Intendance" had to study the nature of the country through which the expedition would have to pass, and to report in what districts they would be able to provide the troops with provisions by means of requisition, and in what districts they would be compelled to use transport. The Officers of the artillery had to give a detailed account of the exact amount of ammunition assumed to be with the Force and in store, and also of the best means of forwarding stores. The Officers of the medical department had to inform themselves as to the formation and construction of military hospitals, and the furnishing them with every requisite. The Officers of the eastern army had to study the military topographical description of the Moscow, Kiev, and Smolensk districts, and in addition to this, they had to draw up a plan for the fortification of Moscow. By this plan it was proposed to fortify Moscow on the western side, to throw up thirteen earthworks, and to place in an efficient state of defence the cemetery and large buildings outside the town. It was calculated by this plan that 10,000 men would be required to defend the fortifications, and that those fortifications would be able to shelter an army of 100,000 men. The Officers of the Intendance had to report upon the best means of providing Moscow with provisions for the space of ten months, and also upon the best

method of despatching supplies to the troops when they were engaged in the field. The Officers of the railway command had to report upon the time required and best means of forwarding an infantry division from Nijni Novgorod to Moscow, and a cavalry brigade from St. Petersburgh to Moscow.

As the conclusion of these preliminary tasks, the commanding Officers on both sides gave their Officers instructions that, during the operations in the field, they would have to make reconnoissances, to prepare routes for marches, to select the best place for camps, bivouacs, &c., to arrange expeditions for foraging, and also from time to time to draw up their men in battle order, and to report upon the best means of fortifying the positions taken up by them by the means of field works, and to give a detailed account of the number of men, and the time that would be employed in throwing up each field work.

With the solution of each tactical problem the Officer would have to furnish a map of the locality, and also a written statement showing the disposition of his troops; and, previous to an assumed assault, a survey would have to be made of all approaches to the position. The Commander-in-Chief of the Moscow district was to be the head umpire. He was to have charge of both sides, and to be assisted by eight senior Officers, who were to aid him in verifying the tasks performed by the Officers in the field. The military medical inspector at Moscow had to verify the work done by the medical men attached to the expedition. A day was allowed for the solution of each more complicated problem; and all the Officers had to keep diaries in which everything they had done in a military sense during the day had to be noted down, and a printed journal was kept on both sides stating the progress of the day's marches, and the course of the manœuvres.

Every morning at 12 o'clock the head umpire sent to the Commander-in-Chief on each side, information as to the enemy, and according to this information they had to make their arrangements and all dispositions, and forward the same in writing to the head umpire, at the same time telling him what had been the tasks performed by the Officers under their command the day before. The head umpire on receiving this information sent back word when, and where, and by whom the tasks would be verified. If the two sides approached so closely that a collision appeared inevitable, the head umpire desired the Commanders-in-Chief on both sides to make all arrangements exactly the same as they would during actual warfare, and that they were to mark out the ground chosen by them by means of the men with flags. During the course of the engagement, the different umpires rode about, and informed the various division leaders and brigade leaders of what was being done by the division leaders and brigade leaders on the opposite side, and according to this information, the division leaders and the Brigadiers had to act. If they changed their position they had to make a rough sketch of the place, and to state how they had disposed of their men. If an infantry regiment had to attack, the commander of the infantry regiment had to design a map, and state exactly the nature of the ground, and how he would have led his men to the assault without exposing them too much to the enemy's fire; or, in case of resisting

an assault, how he would have availed himself of the nature of the ground in the locality. Every order during the manœuvres was sent in writing; for it had been found during the autumn manœuvres at St. Petersburgh, that very often mistakes had arisen. In time of war we know what disastrous consequences may ensue through any error in a message. During these "skeleton manœuvres" every order was sent in writing, and these orders had to be kept for the inspection of the umpire at the end of the day, so that should any mistake arise, the umpire might be able to see whose fault it was, and whether the fault lay with the Officer who sent the order, and who had not worded it properly, or whether the fault lay with the receiver of the message, who had shown a dearth of comprehension. A certain quantity of young Officers were also attached to the expedition to act as "gallopers," to convey messages. They from time to time received written orders for the different division or brigade leaders, with the exact time marked upon the envelope. When they had received them, they then had to ride perhaps six or seven miles, and find their way by means of a map to the person to whom the order was addressed. When he received it, he marked down the exact hour; and the following day the head umpire compared the two times, when it was clearly ascertained whether the Officer had carried the message with due and proper celerity. In addition to this, the Officer who carried the message had to make a rough sketch of the ground over which he had galloped, and to give an account of the nature of the country. The day after a battle, the head-umpire rode over the battle ground with all the Officers' maps and plans, and compared one with the other, and pointed out the mistakes which ought not to have been made, or approved, if he thought it right to do so.

Twenty-one days in all were allotted to these manœuvres; seven days were devoted to preliminary instruction, seven days were allotted to work in the field, and seven days to verifying the problems and tasks performed by the Officers. The following were the tasks that were performed by Officers in the field:—The Officers of the western army fought a battle at Voskresensk, then from that place they made a flank march on the Smolensk high road, and fought three retreating battles as far as Viazma. The Officers of the eastern army fought a battle at Voskresensk, then they made a retreat march to Tooshino and Kinsk, and thence an advance, with three battles, along the Smolensk high road.

At the conclusion of the manœuvres, the Officers of artillery sent in reports to the military authorities, how they would have supplied the forces under their command with ammunition after the battle at Voskresensk. The Officers of "Intendance" reported upon the means they would have employed to remove their baggage when they made their retreat. The medical men also sent in reports as to how they would have supplied their hospitals with every requisite, and how they would have forwarded the wounded to Moscow and Viazma. The other Officers sent in a report of the survey they had made of the River Moskva, and the River Istra. At the conclusion of the manœuvres in the three districts, the chief umpire on each side sent in a detailed report to St.

Petersburgh, and these reports were submitted to the inspection of a board composed of the senior Generals in the Russian army. These Officers, after carefully reading the various remarks, came to the conclusion that these manœuvres are most useful. In the first place, they cost the country very little; secondly, in an enclosed and confined district you can manœuvre with freedom, and without doing any damage to the crops; and, thirdly, you give the opportunity to Colonels and other Field Officers who do not command brigades, during the autumn manœuvres, to command brigades and divisions, and learn the higher commands in warfare. It was resolved that these "skeleton manœuvres" should take place in every military district in Russia, certainly once, if not twice, a year; but that first of all the direction of the manœuvres should be specially confined to the western frontier.

From the various subjects I have brought before you to-day, it would be very easy to make deductions, and possibly to draw comparisons. But if I were to do so it might be misconstrued into an attempt at criticism, so I shall leave it for Officers who are older and far wiser than myself to consider whether any of the systems I have mentioned this afternoon might be beneficial if adopted into our own service.

The CHAIRMAN: I will now ask you to thank the lecturer very much for his kindness in giving a lecture which I am sure is replete with interest, which will interest those who may read it in print, as well as those who have been present to-day.

ERRATUM.

Under the title of "Campbell's Range Indicator," at page 311, vol. xvi, 2nd line from the bottom, *for* "dZ produced is an asymptote to the curve," *read* "dZ produced is parallel to an asymptote to the curve, the distance between the two lines being $= 120\,h$."

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